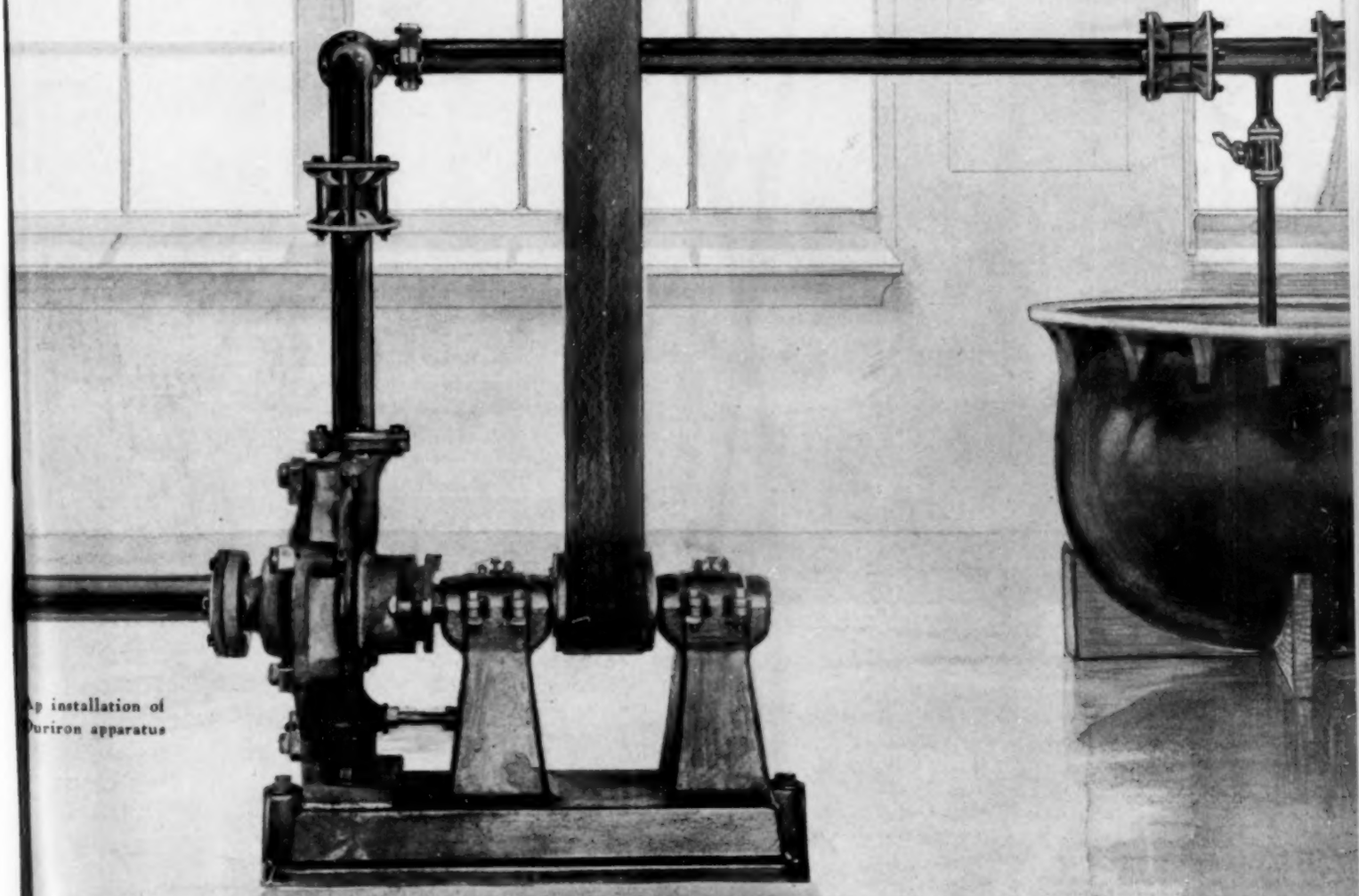
Metallurgical & Chemical Engineering

Volume XII, Number 10 October, 1914 McGraw Publishing Co., Inc.



An installation of Duriron apparatus

The Acid, Alkali and Rust Proof Qualities *of* DURIRON

with its high resistance to Erosion means operating economies for a wide number of industries

Send for sample — Make your own test

DURIRON CASTINGS CO.

Sales Offices

New York City—90 West St. Dayton, Ohio—1307 West Third St.

Agencies

The Yuba Construction Co., San Francisco, Cal.

Stearns-Roger Mfg. Co., Denver, Colorado

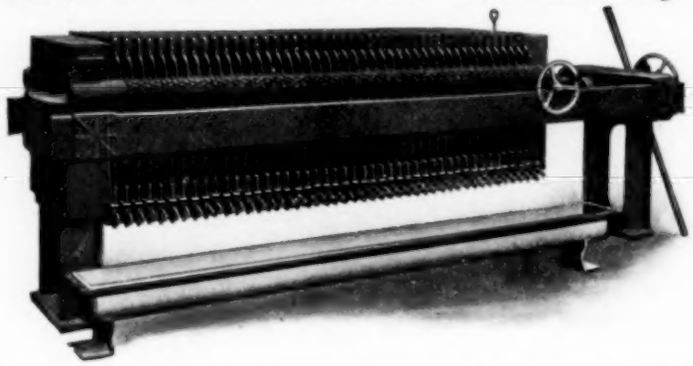
Foundries — Dayton, Ohio

DURIRON Acid Alkali Rust Proof TRADE MARK

Reason No. 3 For Shriver Filter Press Efficiency

From Pig Iron to Finished Press

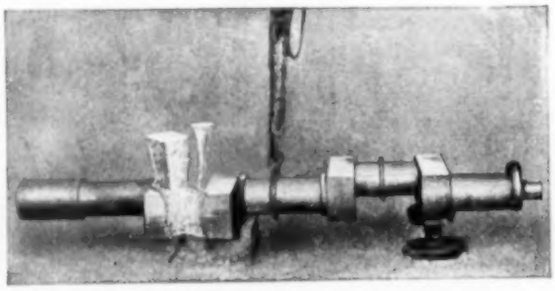
every step is carried on in this one shop of Filter Press Specialists. The casting of the metal, the proportioning of the mixture to assure Shriver strength, the machining to template to assure Shriver Accuracy, and the final assembling and testing to make sure that no detail that goes to make up Shriver Quality is lacking—all is done in one big plant under the personal supervision of men whose life-long business has been building filter presses. You cannot afford to overlook SHRIVER PRESSES: look them over instead.



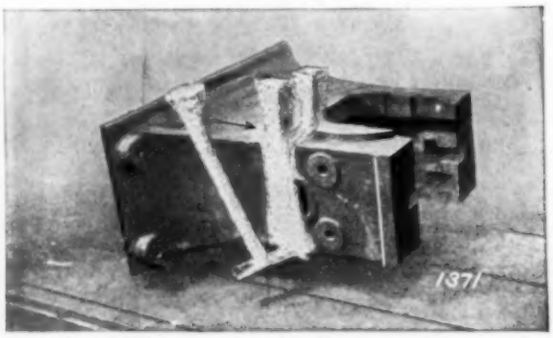
T. SHRIVER & CO.

808 Hamilton St., Harrison. N. J.

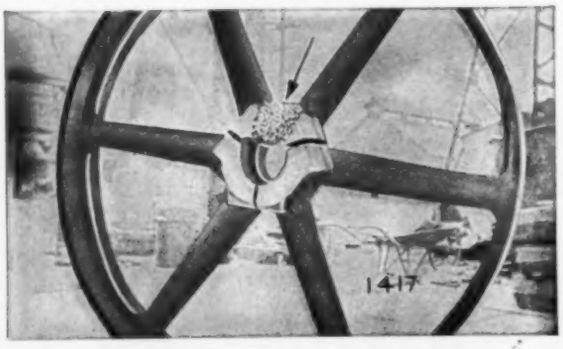
6932



9¼ inch Crankshaft Welded in 49 hours with Thermit.



Thermit Weld on Cast Iron Pillow Block Before Machining.



Thermit Weld on Hub of Cast Iron Pulley.

In Case of A Breakdown Wire our Nearest Office

We weld broken crankshafts, flywheels, spokes, gear wheels, connecting rods and many other sections in quickest time and at least cost.

We give you a PERMANENT repair at very little more than a patch and at a great saving over purchasing a new part.

Repairs executed at either your shops or ours. We undertake work at a moment's notice. **All work guaranteed.**

Don't wait for a breakdown to occur, but write today for full information regarding the Thermit Process of Welding.

Remember the old proverb:
"FOREWARNED, FOREARMED."

Obtain our Pamphlet No. 2941 for your reference files.

THERMIT

Goldschmidt Thermit Company

Wm. C. Cuntz, Gen. Mgr.

90 West Street, New York City

329-333 Folsom St., San Francisco
7300 So. Chicago Ave., Chicago
103 Richmond St. W., Toronto, Ont.

Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII — NEW YORK, OCTOBER, 1914 — NO. 10

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary.
JOHN T. DE MOTT, Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Colo.
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
PHILADELPHIA OFFICE.....Real Estate Trust Building
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50. (European exchange, 10 shillings, 10 marks, 12.50 francs.)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, OCTOBER, 1914.

EDITORIAL:
Chemical Manufacturing Possibilities 611
Grinding Ore for Cyanidation 611
The European War and American Radium Industry 612
The War and American Financing Abroad 613
READERS' VIEWS AND COMMENTS:
The Dependence of Industries on Chemistry. By D. T. Pierce 614
Railroad Electrification as a Relief of Economic Stresses. By Woolsey McA. Johnson 614
Cost Accounting and the Work of Accountants. By Justin H. Haynes 614
Nevada State Mine Rescue and First Aid Meet. By Francis Church Lincoln 615
The Non-Ferrous Metal Market 616
The Western Metallurgical Field 616
The Iron and Steel Market 618
Program of Niagara Falls Meeting of the American Electrochemical Society 619
The Effect of Steam upon Magnesite Brick or Calcined Magnesite. By R. H. Youngman 620
The Determination of Phosphorus in Scheelite Concentrate. By E. W. Hagmaier 620
Grinding Ore for Cyanidation: A Suggested Modification for all Sliming Practice. By W. J. Pentland 621
The Possibilities of Hardwood Distillation on the Pacific Coast. By R. C. Palmer 623
Indeterminate Cases in Mixing Ores for Calculation of Furnace Charges. By Regis Chauvenet 626
Refractometry. By G. A. Shook 630
Cyanide Practice in the Porcupine District, Ont. II. By H. C. Parmelee 636
Chicago Meeting of American Institute of Metals 641
Abstracts of Papers by Lawrence Addicks, George Stone, William A. Cowan, F. O. Clements, S. L. Hoyt, Herbert G. Dorsey, Ernst M. Schmeltz, H. M. St. John, H. W. Gillett and J. M. Lohr, E. B. Guenther, Fred. L. Wolf and Robert B. Burr, H. W. Gillett, G. H. Clamer and Carl Hering.
NOTES ON CHEMISTRY AND METALLURGY IN GREAT BRITAIN 650
SYNOPSIS OF CHEMICAL AND METALLURGICAL LITERATURE 653
RECENT CHEMICAL AND METALLURGICAL PATENTS 657
Temperature Control for Industrial Purposes 660
Preparing a Crank Shaft by Autogenous Welding 662
Recording Gas Calorimeter 663
Large Oil Engine 663
American Manufacturers and the European War 663
Personal 665
Obituary 666
DIGEST OF ELECTROCHEMICAL U. S. PATENTS (Electroplating) 666
BOOK REVIEWS 668

Chemical Manufacturing Possibilities

One of the big problems which this country faces as a result of the European war is the possibility of producing such chemicals as have not yet been successfully produced here on a large scale in competition with Europe, though their production is technically possible in this country in so far as the raw materials are available. The production of dyestuffs is the most notable example. Two lines of thought suggest themselves in connection with this problem.

The first is that the problem is in no way technical. It is purely economic. To the concise yet exhaustive summary of the situation by Dr. Bernhard C. Hesse in our last issue we have nothing to add here but the advice that those interested in the matter should read it again and again. If they did, there would be less foolish talk of lack of spunk in American manufacturers. What is lacking in reality and what is lacking absolutely is a reasonable guarantee that the enormous investment required will not be a total loss as soon as the war is over and the imported dyes and other chemicals can be put on the American market again at the old prices. It seems too much to hope that the consumer—the American textile industry in the case of dyestuffs—would stick to the more expensive home product for reasons of patriotism. Clearly nothing is left but a high tariff and the certainty that the people at large so thoroughly understand the situation as to guarantee the tariff remaining in force for a reasonably long period.

A second line of thought is whether coöperation with European manufacturers in this matter would not be economically preferable to competition. It is a fact that, as a result of the war, American financiers have discovered that industrial chemistry is more than a string of drugstores and are willing to invest heavily in new American chemical industries. It is also reasonable to assume that European manufacturers are beginning to recognize that they would be better off now if they had American factories, even if they had to operate them under a decided handicap. It would be eminently safe and sane for American financiers and European manufacturers to come together.

Grinding Ore for Cyanidation

When a metallurgical process becomes as firmly established as in the case of cyanidation, we no longer anticipate great or revolutionary changes to take place in its application. In a degree the method becomes standardized due to long and varied experience. Then the largest opportunity for improvement lies in the alteration of some detail to meet special conditions. This, in turn, results in standardizing the practice in certain

countries or localities where special economic or metallurgical requirements have to be met. Thus we distinguish broadly between the combination sand-slime method and all-sliming practice. Differences in detail of both methods arise from the introduction of amalgamation or concentration.

We are pleased to present elsewhere in this issue a novel proposal for the modification of all-sliming as generally practiced. The author, Mr. W. J. Pentland, is an operator experienced in the practice of cyanidation in Mexico, where silver ores have been so successfully treated by that process. His suggestion is not offered as being of broad general application, but rather as a detail susceptible of use in special cases. Essentially it involves the introduction of an agitator in the tubemill-classifier circuit, in order to give the separated and reground sand the special treatment it may require, instead of submitting the entire pulp to a treatment demanded by only a refractory, and sometimes small, portion of it.

As we have pointed out above, the suggestion is in line with the trend of metallurgical development—introducing modifications in detail to meet special needs. In view of the different character of so-called sand and slime produced in crushing, it is easily conceivable that, in some instances, the former may be more refractory and require longer time of contact and stronger solution than the latter. In such a case it would appear rational to provide these conditions, in view of the arguments advanced by Mr. Pentland. The proposal will be of interest to cyanide metallurgists, who are cordially invited to offer discussion on the subject.

The War and American Radium Industry

The bills introduced in both houses of Congress early this year, providing for conservation of radium-bearing mineral land and participation by the government in the business of producing radium, have been reposing quietly in the proverbial pigeon-hole. Considering the tempest which these measures precipitated for a brief time, the long period of calm that has followed might be considered as ominous of their approaching death due to desertion and neglect. The Senate bill is the poorer of the two, but the House bill could easily be modified and made acceptable.

By reason of various tactics employed to delay consideration of the bills, they lost their place on the calendar; but it is quite certain that they will come up again with the government's conservation measures. So much time has elapsed that the principal reason urged by the proponents of this legislation—conservation of radium in the public domain—is now less apparent than formerly, for the prospectors have long since taken their cue from the agitation last spring and located all the outcropping or known deposits of radium-bearing minerals. Land that would now be affected by withdrawal would probably be difficult to prospect, but there is still a chance for the discovery of mineral on such land.

But the advent of the European war has put a different phase on our radium industry, because the old-world markets are now closed to American ore. In fact, there is no market, and even the largest American producer of carnotite and manufacturer of radium has closed its own mines. This has developed a demand from smaller producers for an American market, and quite naturally they now beseech the government to enter the field, buy ores and make radium. It is rather amusing to observe the change in sentiment among owners of radium-bearing land since last spring. Some of the government's most active opponents at that time are now eleventh-hour converts to the conservation policy and are urging the passage of a bill to authorize federal operation of a plant to produce radium, so that a domestic market shall be created. Petitions from the San Juan district of Colorado have been forwarded to Washington, urging governmental action.

The mill of the National Radium Institute at Denver is in successful operation under the direction of the Bureau of Mines. The fact that the plant is to be doubled in size is an indication that the results obtained in the first unit are satisfactory to the backers of the project. Likewise, the success of the government's technical staff in this instance has stimulated the present reaction of mine owners in favor of federal operation of a custom mill.

Incidentally, it is of interest to the American radium industry to note that S. C. Lind and C. F. Whittemore, chemists in the Denver office of the Bureau of Mines, have just completed a research, noted elsewhere in this issue, that establishes the normal ratio of radium to uranium in carnotite, just as in pitchblende. Former determinations indicated a low ratio in carnotite, and as a consequence some European buyers have insisted on making an allowance for the supposed deficiency. The establishment of the normal ratio will have a beneficial effect on the American industry, for carnotite in Colorado and Utah now constitutes the world's largest known source of radium.

The War and American Financing Abroad

Immediately upon the outbreak of the European war two thoughts arose in the American mind, first that merchandise exports from the United States would be greatly increased, second, that unless prevented by drastic measures there would be an avalanche of offerings in the American market of domestic securities held abroad. To avoid the avalanche of securities the stock exchanges were promptly closed and efforts were made to hinder the exportation of gold whereby the sale in the United States of foreign held securities might be restricted. To provide for the exportation of merchandise it was everywhere urged that an American merchant marine of large proportions should at once be provided, evidently upon the hasty assumption that the establishment of shipping facilities constituted the greatest desideratum in the new conditions suddenly thrust upon the United States.

Time and reflection have shown both these thoughts to be fundamentally unsound. As to the sale of our

securities by foreign holders, no forecast could reasonably be made, for the foreign investors are individuals, not nations. The fact that the earning power of American corporations would be vastly less affected than the earning power of many foreign corporations might or might not dispose the foreign investor to sell the American securities first. As to the exportation of American merchandise, it has been already developed very clearly that it is not lack of ocean carrying facilities but inability of foreign buyers to finance purchases and effect payment through the purchase of exchange or the establishment of New York credit that is restricting our merchandise export movement.

The analysis of the real problem presented is simple, and yet there is evidence that it is not generally understood. We must pay as we go in the future, as we have done in the past, yet we have reached the present time without ascertaining with any degree of accuracy how we have paid in the past.

It is only now that an investigation is being conducted, for by the war condition, into the quantity of American securities held abroad, yet the sale of those securities has been one of the important items in what is called the unseen balance of trade. Estimates, or rather guesses, currently made at wide ranges on either side of five billion dollars prove how vague has been our information in the past. While we may soon ascertain the volume of American securities held abroad at the present time, we have missed the opportunity of knowing what the volume has been at various times in the past, and thus we are unable to study intelligently the course of our foreign trade. We have paraded figures of the value set upon merchandise, gold and silver exports and imports for many years, apparently ignoring the fact that precise information on these heads is practically valueless unless we know also the items constituting the invisible balance, freights paid for foreign vessel owners, expenditures of American tourists abroad, remittance from the United States of foreign born workmen, premiums paid to foreign insurance companies and various other items, but perhaps the most important of all, the flow of securities and the interest and dividends paid upon them to foreign holders. If we had all the items in the visible and invisible balances of trade they would, of course, balance to a cent, but we lack accurate information upon so many of the items that we cannot even strike a balance by difference, representing some single unknown difference.

It is no less than a public calamity that we do not know how the ledger stands at this tremendously critical juncture. If we had this information we could do with confidence much that we may now shrink from doing even as an experiment. What is left us in our ignorance is merely to endeavor to guess how new items will be added to the ledger in the future. We expect our merchandise imports to be decreased, and we hope that our merchandise exports will be increased. Obviously we cannot expect settlement in gold. From the resumption of specie payments in 1879, through the year 1896, we had net gold exports of $130,000,000, being unable, to that extent, to retain the gold we had plus our own current production. From 1897 to date we have had net gold imports of $290,000,000, and so greatly did the tide turn in our favor that we cannot export any further change of importance, which would bear any measurably important relation to our merchandise movement, seeing that of late our annual merchandise movement has been measured in billions, more than two billions of exports and one and a half billions of imports.

Further prospective changes in the additions to our ledger account are reductions in the expenditures of American tourists abroad and in payments of freight charges to foreign vessel owners. With an increase in the favorable balance in merchandise, in what item is the final settlement to be made? Obviously, in the return of our securities held abroad, or in our purchase of foreign securities. By as much as our securities are returned, by so much will interest and dividend payments to foreign holders be reduced, thus adding annually to the amount that must be liquidated.

It has became well recognized in recent weeks that for foreign countries, particularly South American countries, to buy our goods, their projects must be financed. The financing can no longer be done in Europe. Thus far the current thought seems to be that this constitutes a painful necessity, one that we may not be able to meet. Instead, the view should be that this constitutes a welcome opportunity. The trends of trade should be such as to enable us to do this financing, and gradually to become, instead of a debtor nation, an investor nation. Occasionally our mining and metallurgical experts have gone forth from the country and upon developing a prospect in some foreign land have gone to England or the Continent for the funds necessary to develop it. Obviously the expert's standing in the foreign money marts has been less secure than that of foreign experts, dealing with their own countrymen. A new era in the progress of the United States has now arrived, and the American expert who develops opportunities for profitable devolpments in new countries should be able to find the needed capital at home.

American bankers, who have been so woefully narrow minded as not even to ascertain the volume of American securities held abroad, should reform instantly and post themselves as to what is going on in the world. Wonderful opportunities lie before them as to development in South America and elsewhere, and the trends of commerce in the next few years are going to place in their hands large funds for which it will be their duty to find profitable investment. If the opportunities are properly grasped, confidence in the future of American industry and finance will operate very largely to deter foreign holders from returning our securities to us. Such as are offered at bargain prices should be gladly bought. The question should not be how we can avoid buying them, but how we can buy them to our profit, or become so prosperous that they will not be offered. Courage, rather than fear, should be the spirit in which the problem is attacked.

Readers' Views and Comments

The Dependence of Industries on Chemistry

To the Editor of Metallurgical & Chemical Engineering:

SIR:—"It is, however, unfortunately to be feared that a very large number of lines of manufacture will probably have to depend upon the chemical industry for advice and technical assistance."

What horrid treason is this that rears its head in the editorial pages of *Metallurgical and Chemical Engineering*, of all places? Is it a misfortune to be obliged to depend upon the "chemical industry"? That is a question I cannot answer. But I can speak for a company that depends very largely upon the chemical *profession*, and to those who are facing a similar fate I send a word of cheer and encouragement. It is not a fate so sad as to be unendurable; in fact one grows to like it, though shirt-sleeved plant managers tear their hair and declaim that "a lot of damn high-brows are running the company."

More seriously speaking, will it not be a very good thing for American industry if, owing to the exigencies of the European war, the rule of chemical reason is substituted for the rule of thumb? And will not the same circumstances lead to the perfection of many processes that have not been made "commercially available" heretofore because it was easier or cheaper to depend upon Europe?

Notwithstanding all of the above, the writer perfectly appreciates the whimsical sarcasm of the sentence quoted above from your September editorial on The European War.

D. T. PIERCE.

The Barber Asphalt Paving Company,
Philadelphia, Pa.

Railroad Electrification as a Relief of Economic Stresses

To the Editor of Metallurgical & Chemical Engineering:

SIR:—We all know and are keenly and painfully aware that this is a time of stress even in the United States. But fortunately our people are sinking individual differences and exhibiting a spirit of co-operation and there is true leadership by our big men, who rule not by divine right of natal succession but by the noble divine right of ability. To enable some such men to consider an idea of mine which I trust will be practicalized in some way for common good, I submit to the perusal of your readers the following proposal and argument thereupon.

Public financial opinion is right fearful and apprehensive about three things in main. These are the disposal of the cotton crop, the copper industry, and the possibility that several billion dollars' worth of railroad securities will be dumped on our stock market. Other disturbing factors are small compared with the above big three. In 1893-6, municipalities put unemployed artisans to work on the public roads. These men were not bums but good, earnest men, who wished to work. My idea is that we should adopt a similar scheme—only in a scientific, efficient, and national manner—that is, that by energetic methods we should start next spring the electrification of such portions of our railroads as are clearly to be benefited thereby.

Competent electrical engineers state that in cases where there is great density of traffic or steep grades or heavy train loads the electrical method is the economical method. The same way of steel will carry more people and goods and it is not good engineering economics to put a 2000-kw power house on wheels. Fortunately there have been tried out several systems of electrification of trunk lines, and it is not a hazy issue, but one definite and worked out. My scheme would be to start a general electrification of our steel highways, give honest labor to honest people, and build up a much-needed permanent public improvement.

The railroads, shipper and people are in this province controlled and dominated by the Interstate Commerce Commission. This judicial administratory board fixes rates and adjusts differences. It has been well argued that this board should set its seal of approval on all emissions of railroad securities.

Should such a plan as I have outlined be proposed and the electrification of our large trunk lines start in a comprehensive and intense manner, and should the Interstate Commerce Commission allow the emissions of securities bearing a high rate of interest and with liberal provisions for amortization and depreciation due to advance in the state of art, and such increase in rates as would justify such an expansion, the good effects would be incalculable and as widespread as a rain from heaven in time of drought, which falls on the just and on the unjust.

The copper mining, smelting, and refining industry would flourish. The business of fabricating copper and the electrical industry would revive. The steel and iron trade would be helped. Our energy that might go to waste would be put in useful permanent form.

If such securities ware made safe investments by care and intelligence, and if some of them were so strong that they were legal for savings banks, the money would flow in an endless chain, provided such people as were benefited kept their mental equilibrium.

The collateral problem of our country is to prevent waste not so much by stern necessity as by wisdom and thrift. If we can hold together in spirit, we can emerge from the crisis far stronger than we entered it. High rates of interest will draw out capital from its hiding and keep gold in the United States. Just now the banks are borrowing money at 3 per cent from the Government and loaning it to the people at from 8 per cent to 10 per cent. Good business indeed both for people and the banks, provided the banks put credit in safe hands and the people can earn enough with the capital to pay the increased rates.

This national electrification of railroads must be conditioned on high rates of return. This limitation is in line with the theory propounded and exposited in *Metallurgical and Chemical Engineering* that applied science has opened up as it were a new virgin country where profits are large and usufruct of capital and intelligence is great.

The scheme that I propose is not a chimerical one, at least its benefits would not be ephemeral. Of course, I know that I have elaborated it and elucidated it in the roughest sort of pencil sketch. But put on the drafting board in clear and precise form, it would be a magnificent plan of commercial engineering.

WOOLSEY MCA. JOHNSON.

Hartford, Conn.

Cost Accounting and the Work of Accountants

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In reply to Mr. Ernest G. Ashby's discussion of my article on metallurgical cost keeping, I believe that in the main we agree except as to the title of the employee who calculates the cost data.

It might be inferred from my article that this should

fall on the engineer. This is not my intention. There should be someone whose duties are to keep cost data available to the executive, to enable him to deal in detail with his problem. This man should preferably be both an accountant and an engineer. This is usually impossible. If he is an accountant, he should give such cost data as may be prescribed by the engineer, superintendent, etc., and not by the auditor or office force.

The vital point of the entire matter, to my mind, lies in the unit system. Then the particular unit used becomes paramount. Not many systems carry milling costs on any unit basis, except the per ton basis. This unit is based on the number of tons milled. For example: A mill handles 500 tons of ore through the stamps in twenty-four hours. Say 400 tons of this is then slimed in the tube-mills. Is the cost of tube-milling calculated as it should be on the 400-ton basis, or is it wrongly calculated on a 500-ton basis?

The foundation of efficiency is the largest accomplishment for the least expenditure. The words "largest" and "least" are the superlative degrees of comparison. Therefore, costs must be expressed in units capable of comparison to be of any value to the executive. For instance: In the 1913 report of the Alaska Treadwell Gold Mining Company it is stated that pumping costs 10 cents per ton of ore milled. From this simple statement, can anyone state whether that pumping was efficiently done or not? From a cost analysis point of view this should be stated in gallons-feet. To say that pumping costs 10 cents per ton of ore milled is meaningless and worthless and in itself gives the engineer or superintendent no idea of the efficiency of the work.

I admit that the above figure is sufficient for the stockholder, but it does not indicate the efficiency of the pumps to the superintendent.

Naturally these results can be dug out of any system of bookkeeping, but it is my experience that when this is necessary they are never dug. These facts should not only be readily obtainable, but they should show on the regular reports so that any sudden change manifests itself at once.

As usual, an accountant cannot accept any set of figures that do not check to the cent. I still maintain that cost keeping contains errors in spite of the most rigid system, but as long as they allow comparisons, the errors are negligible.

In considering costs, as stated above, comparisons are the vital point of all systems. Halbert T. Gillette in his "Hand Book of Cost Data" goes as far as to say:

"Since cost keeping has as its primary object the reduction of costs, since comparison of results secured by different men or different machines or different methods are necessary, it follows that standard wages and standard prices of materials must be used. It may happen that on one job the cement may be purchased at different times at prices ranging from $1.20 to $1.50 per barrel, and that common laborers may receive from $1.50 to $1.75 a day. In comparing unit costs a standard price of cement should be assumed as $1.30 per barrel and a common labor standard wage as $1.50 per day. Then comparisons become possible. A bookkeeper cannot assume any rate of wage or any price; he must give the actual wage or price. A cost keeper usually finds it desirable to use standard wages or prices which approximate the average, or actually are the average."

The cards shown in my article are merely one form for obtaining this data on a unit basis. Even more than unit measurements are necessary, according to Gillette:

"Cost keeping records should state conditions, such as weather, distance of haul, etc., which are essential to interpretation of results. Sketches showing design of structure should form part of permanent cost records. Such things are entirely foreign to bookkeeping, and if placed upon bookkeeping records simply serve to confuse them."

I agree with Mr. Ashby that the accounting and engineering departments must work together, but I object to the accounting department determining what cost data the engineering department shall use. This may not be so in Mr. Ashby's case, but I am certainly warranted in saying that in most cases the engineering department must accept the cost data as given to them.

JUSTIN H. HAYNES.

Denver, Colo.

Nevada State Mine Rescue and First Aid Meet

To the Editor of Metallurgical & Chemical Engineering:

SIR.—The Nevada State Mine Rescue and First Aid Contest, held on the Mackay Athletic Field of the University of Nevada at Reno, Nevada, on Labor Day, September 7, 1914, was of particular interest in several respects. It was the first strictly metal mine meet to be held in the United States, and the first mine rescue meet to employ a mine rescue maneuver.

Prior to this meet, car No. 5 of the United States Bureau of Mines had been touring the State of Nevada, and the miners who paticipated had been trained by Mr. E. Steidle, mining engineer, and Mr. George W. Riggs, first-aid instructor, both attached to this car. They trained sixty-nine miners and ten students of the University of Nevada in mine-rescue work, and one hundred and thirty miners and fiteen students in mine first-aid work. In addition to this, Mr. Steidle gave week-end lectures on mine rescue and first aid, reaching in all some forty-four hundred miners.

The distribution of the men, who were trained in the work, is shown in the following table:

Mining Districts	Men Trained in Mine Rescue Work	Men Trained in Mine First Aid	Number of Oxygen Breathing Machines
Ely	10	40	6
Virginia City	10	10	7
Goldfield	10	10	6
Tonopah	24	30	13
Round Mountain	5	10	2
Blair	0	10	0
Wonder	5	10	2
Fairview	5	10	2
University of Nevada	10	15	1
Total	79	145	41

The contest held at Reno was under the auspices of the Engineering College of the University of Nevada, with the co-operation of the U. S. Bureau of Mines, the American Red Cross Society and the Nevada Industrial Safety Association.

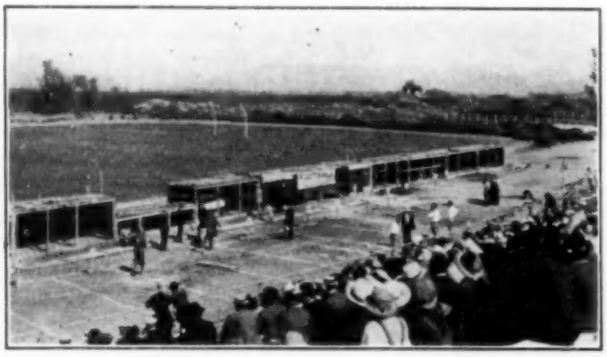
In the mine rescue problem a model drift, constructed of timber, lathes and tarred paper, after a design by Mr. Steidle, was employed. This drift was open on the side toward the grand stand, with the exception of one section, which was closed by means of windows, and in which dangerous gases were confined. The drift was 6 in. in height and 260 in. in length and was made up of the following sections: 80 in. of open drift, 20 in. of drift in which a hanging fall was supposed to have taken place and which was, therefore, only 3 in. in height; 20 in. more of open drift, a 40-in. gas and smoke chamber with an inclined obstacle in the center, 20 in. of open drift, 20 in. in which a fall was supposed to have taken place and in which an opening 3 in. high was left above the fall, and finally 60 in. of open drift to the face.

The participants were examined by doctors and then tested and adjusted their apparatus and stood a three-minute trial in a small test-house filled with gas and smoke. Then each team in turn entered the model drift to rescue a miner, supposed to be overcome near the face. Stretcher and breathing apparatus were carried for the use of the injured miner, and a life line was

used, and all precautions were taken as suggested by the U. S. Bureau of Mines.

The first prize was won by the Tonopah Mining Company's team. The three other competing teams were from the Veteran Mine of the Nevada Consolidated Copper Company; the Tonopah Belmont Development Company, and the Goldfield Consolidated Mines Company.

Eight teams took part in the Miner's First Aid Contest. The problem in this contest was to aid a miner found in a drift, under a fall of rock, in contact with electric wire, unconscious and suffering from numerous injuries. The first prize was won by the McGill Concentrator team of the Nevada Consolidated Copper Company. The other contestants were the Tonopah Exten-



NEVADA STATE MINE RESCUE AND FIRST-AID MEET

sion Mining Company, the Tonopah Belmont Development Company, the West End Consolidated Mining Company, the Goldfield Consolidated Mines Company, the Tonopah Mining Company and the Veteran Mines of the Nevada Consolidated Copper Company. Three teams of University students contested among themselves.

The first prizes were a silver shield and a silver loving cup, presented by the Nevada Industrial Safety Association to the winning teams, while the American Mine Safety Association presented medals to the individual members of these teams. The other prizes distributed in these contests included subscriptions to *Metallurgical & Chemical Engineering* and other technical papers contributed by the publishers, and miners' lamps donated by manufacturers.

FRANCIS CHURCH LINCOLN.

Mackay School of Mines,
University of Nevada.

The Non-Ferrous Metal Market

For sixty days the domestic market for non-ferrous metals has been subject to serious disturbance with wide fluctuations in prices. Curiously enough, different metals have been variously affected, to advantage in some cases and unfavorable in others.

Copper.—There has been no wholesale market for this metal for some weeks, and no quotations are available. American producers have acted as a unit in curtailing production about one-half, which will practically compensate the loss of the foreign market, and it is expected that the market will be in good shape when business can be resumed on a normal scale.

Tin.—Quotations in this market are still nominal, and with an increasing supply have tended to fall off. The fancy prices asked during August have disappeared, and late quotations are about 33 cents, New York.

Lead.—This market has remained weak, and the price of 3.90 cents, New York, has been maintained by the A. S. & R. Co.

Spelter.—Prices for this metal have receded from the high figures qnoted shortly after the war began. Demand has now become slack. A high price of 6.10 cents was reached on August 26, since which time a steady decline has occurred. Latest quotations are about 5.50@5.65 cents, St. Louis, and 5.65@5.70, New York.

Other Metals.—Prices for antimony have risen to from 10½ to 12½ cents for various brands. Aluminium is quiet at 20@20½ cents, New York. Quicksilver showed a stiff advance in price, and is quoted at $75@$85 per flask of 75 lb., New York, about double the prices before the war.

The Western Metallurgical Field

Smelter-Fume Damage in Salt Lake Valley

Study of the smelter-fume problem and the effect of smelter gases on agricultural crops is being conducted by the companies operating in the vicinity of Salt Lake City, Utah. The result to date is that two of the plants, those of the United States Smelting Co., at Midvale, and the American Smelting & Refining Co., at Murray, are fumeless as far as the discharge of visible gas is concerned. In fact, to a stranger the plants have the appearance of being closed and not in operation. The Garfield Smelting Works, however, situated at the north point of the Oquirrh range, west of Salt Lake City, continues to discharge into the atmosphere the gases from the smelting and roasting furnaces. The same is true of the Tooele plant of the International Smelting & Refining Co., situated southwest of Salt Lake City, on the western side of the Oquirrh mountains.

Both the Midvale and Murray smelters use the Sprague process for neutralizing the sulphuric acid in the gases, and the products are collected in bag houses. This still leaves sulphur dioxide unaffected, and this gas is discharged into the air. Under normal weather conditions the ill effect of smelter fume in the valley has been greatly minimized due to these improvements, but this year the damage has been increased, due to an unusual snow storm which occurred in June. The average quantity of sulphur dioxide in the valley atmosphere south of Salt Lake City is about 0.25 part per million. The highest is one part per million, and this is observed when northwesterly winds blow fumes from the Garfield smelter over the valley. The lowest quantity observed is a trace, and this condition exists when northerly winds clear the valley of fumes. In spite of the improvement in conditions, however, and the effort of the smelters to meet the imposed requirements, there is more or less friction with the farmers, and damage suits aggregating hundreds of thousands of dollars are pending against the smelters. The Murray plant is said to be working under an agreement with the farmers for compensation for damage, and the Midvale smelter is reported to be seeking a legal modification of restrictions whereby it can smelt an increased daily tonnage of sulphide ores.

Some interesting experimental work is being done by the American Smelting & Refining Co., which has purchased a farm three miles north of the Murray plant. This farm comprises 50 acres of ground, and was one of the poorest farms in the valley. It is not only in the zone of possible fume damage, but it contains an undrained area and some alkali spots, and is therefore suited to the study of a variety of causes of poor crops. On this farm the smelting company has erected a laboratory where a corps of experts conduct their studies. Field tests of the effect of different percentages of sulphur dioxide on various growing crops are made, and the results recorded for future use. Studies are also made

of the diseases of local crops and of the various insects which affect the yield. These pathological studies already have resulted in the discovery of bacterial and fungus diseases, the effects of which the farmer has attributed to smelter fume.

The attitude of the American smelting company to the farmer is one that should improve relations between the two interests. The experimental farm is being conducted not only in the interest of the smelter, but it serves also as a demonstration farm for the local farmers. The latter are encouraged to visit the farm, and are given instruction by the experts on methods of improving their farm work. They are shown also the effect of various diseases on crops and are taught how to eradicate the troubles which are not due to smelter smoke. Instead of antagonizing the farmers and claiming that no damage is done, the smelter is apparently admitting evident damage, at the same time protecting itself against imposition. It is an odd fact that farmers in the zone of actual damage are most reasonable and easiest to deal with, while those who are outside the zone of damage cause a great deal of trouble. The work of the American Smelting & Refining Co. should go a long way toward creating a better spirit between the contending factions, as well as determining in a scientific way the actual damage of sulphur dioxide, and gaining a basis for settlement of damage claims.

The War and the Metallurgical Industry

The state of uncertainty which prevailed in the mining and metallurgical industries immediately following the declaration of war in Europe has largely been replaced by a spirit of optimism and assurance that accompanied a calm study of the situation. With the exception of the curtailment in copper production, there have been no serious disturbances in the metal producing centers of the West. The slump in silver was but temporary and due only to the fact that smelters did not know where they were to dispose of their stocks; hence they could not assure the miner a normal price for his silver ore. The Cobalt district in Canada was vitally concerned, but even there the bullion shipments have resumed their normal proportions, and many companies have resumed operations after a short period of non-production.

Up to the present the lead market has not shown the activity or rise in price anticipated by many operators. Nevertheless, according to well informed smelting officials, it is almost certain that lead will show an advance in the near future. In fact, the head of one of the largest smelting concerns is quoted in the public press as saying that the United States is on the eve of a great opportunity in all commercial lines, and has a chance to supply the world with needed metals. Metal manufacturing industries are suggested as a logical development in order to take care of our excess metal production.

As anticipated, the spelter market has enjoyed a prosperous turn. A stimulus has been given to zinc mining, milling and smelting, and such centers as Joplin have experienced a revival of interest such as has not been known for years. Old properties have been reopened; old mills put in commission; dumps leased for operation, and prospecting stimulated.

The United States Geological Survey has shown commendable activity in issuing so promptly various bulletins on our mining and metallurgical industries. One of the most important is *Bulletin* 599, "Our Mineral Reserves—How to Make America Industrially Independent." It contains an inventory of our mineral resources, and gives some details on fuels, metals and non-metallic minerals of commercial importance. In addition to this, numerous press bulletins have been issued giving authoritative comment on the status of the metals.

From the chemical point of view, the situation in the West is most concerned with the supply of cyanide, and the possibility of domestic production supplying the demand. Such as are interested in the prospect of making cyanide we refer to back files of this journal, in which will be found many technical articles dealing with this industry. Particularly in our issues for March and April of the current volume will be found articles on the manufacture of cyanide and cyanamide, the latter product being of immediate interest as a possible source of the former.

Western metallurgical works, as well as custom chemists and assayers, have suddenly found that their dependence on European manufacturers is greater than they had hitherto thought, particularly for chemicals and filter papers. Prices of these articles have increased several fold and the supply is at present limited. Among other articles affected by the war are graphite, barytes, manganese, tin, arsenic, antimony, radium, potash, zinc dust and flint pebbles. In the case of some of these and other materials, we have been dependent on Europe for supplies in quality as well as quantity, and the present situation emphasizes the importance of developing as far as possible our own resources along these lines. Time will be required to get new industries started, and even then our manufacturers must give consideration to the possibility of maintaining their markets after conditions in Europe return to normal.

Among the large copper companies, Utah Copper Co. will pay the usual dividend for the quarter ending with September. Chino has reduced the rate from 75 cents to 50 cents for the current quarter, and Ray Consolidated and Nevada Consolidated have passed the dividends.

Pneumatic Flotation Process

New methods of accomplishing ore flotation are being rapidly developed, and a wide variety of means used to accomplish the purpose. One of the most interesting as well as successful methods is that of using air as the agitating and froth-producing medium. Plants using this method have been installed by the General Engineering Co., of Salt Lake City, Utah, at the National mill, in Idaho, the Magma, Miami and Inspiration in Arizona. The ore is mixed with oil and water and fed into a separator which consists of a rectangular cell having an inclined false bottom covered with fabric. Compressed air admitted into compartments below the false bottom passes upward through the fabric and is divided into innumerable small bubbles which form a froth 12 to 18 inches deep in the cell. Mineral concentrate rises with this froth and overflows the sides of the cell, while gangue flows down the inclined bottom and is discharged. If desired, the first cell can be used as a rough concentrator, and the valuable product re-treated in another cell. The products from several roughers could be combined on one cleaner. Pine oil has been found to be a good floating medium, and is used in the oil mixture in varying proportions.

Camp Bird and Santa Gertrudis

These two English companies controlling the Camp Bird mine in Colorado and the Santa Gertrudis in Pachuca, Mexico, have become suddenly involved in financial loss due to the collapse of commercial enterprises in which the former chairman of the companies, Mr. A. M. Grenfell, was interested, and in which funds of the mining companies were invested or on deposit. In an official statement issued by Mr. H. C. Hoover, who has accepted temporarily the chairmanship of both companies, it is announced that the probable total loss will not be as great as at first anticipated. Camp Bird

probably will sustain a loss of $50,000, and Santa Gertrudis $135,000. Both companies, however, are sound mining and metallurgical enterprises, and will not be seriously crippled by these losses. The Santa Gertrudis mill has been closed owing to disturbances in Mexico, but the Camp Bird is in operation.

Butte & Superior

It is reported that July operations at this property in Montana showed an improvement in milling results. The former recovery of 90% was maintained and at the same time the grade of zinc concentrate was raised from 51.73% in the first quarter to 55% early in July. These concentrates are sold on a 50% zinc basis, and any improvement over that grade brings a premium, just as a deficiency entails a penalty. The property is now operating under normal conditions, producing and treating about 1000 tons of ore per day.

Model Town at Anaconda

It is reported that the Anaconda Copper Mining Company, through its subsidiary, the Deer Lodge Valley Farms Company, is to establish a model town for the employees of the smelter at Anaconda. The new settlement will be known as Opportunity. It is located east of Anaconda in the Deer Lodge Valley, where a large acreage has been divided into five and ten acre tracts on which the smeltermen may establish a home and garden plot. The Anaconda trolley system will be extended to the new town, and the Anaconda company will assist the new settlers in every way to establish themselves in comfortable homes. The scheme includes the establishment of legitimate forms of amusement for adults and children, but saloons are barred.

The Iron and Steel Market

The great uncertainties attending any attempt to forecast even roughly the effects of the European war, as referred to in our report a month ago, have been only slightly reduced by the progress of time. It was impossible to judge of the prospects by precedents, for of precedents there were absolutely none. For judgment at the present time we have nothing but the concrete experience of two months and that is very far from conclusive.

The buying power of the so-called neutral or consuming countries has been vastly reduced. Financing of new projects has practically ceased, and funds are usually lacking even for making purchases for current and everyday consumption. When funds are available it is difficult to purchase exchange or to establish London or New York credit. Despite the fact that Germany, France and Belgium are physically unable to export any considerable quantity of iron and steel, and Great Britain's manufacturing resources are somewhat curtailed, the demand from neutral markets is curtailed so much more that Great Britain is unable to sell all the goods she can produce. To the United States there has come little inquiry from neutral markets, and the small iron and steel export trade the United States was conducting just before the war, amounting to about 140,000 tons a month, has not been fully restored, and may not be for several months.

The early idea that the chief desideratum for an iron and steel export trade was ocean-carrying facilities, was quite promptly exploded. Exports to Canada, which move entirely by rail, have been greatly reduced. The fact that war has throttled buying capacity, rather than shut off supplies, is indeed proved by the remarkable case of the United States itself. As indicated in the review a month ago, a first effect of the war was to encourage buying in a few quarters, by fear of possible scarcity later, but even at the outset this tendency was slight. The more important trend then mentioned, as to a stoppage of new projects requiring financing, is now being felt in full force, and even purchases for ordinary current requirements are greatly reduced. The total volume of buying in the United States is considerably diminished.

Steel mill operations are necessarily decreasing, but the decrease lags behind the decrease in buying through, there having been on order books a moderate accumulation of business. While the steel mills operated at nearly 70 per cent. of capacity in July, at the close of September they are operating at not more than 50 per cent and all the prospects are that the rate will diminish further, and probably to the smallest percentage of capacity that has ever obtained in the history of the American steel trade.

The more distant future of the American steel industry cannot be the subject even of intelligent guessing. An illustration of the wide uncertainties may be of interest. Through the refinements of modern practice the amount of coal involved in the production of a ton of finished steel has been very greatly reduced and by reason of this the iron and steel developments in the great Minette ore district have been rapid in recent years. These developments have been on both the German and the French side, but when the war is over there is every reason to believe that practically the whole district will be either German or French. If German, that country will probably include Belgium also, and Germany would then be a close second to the United States in iron and steel production instead of a relatively distant second. If the territory falls to France, that country will rank second and Germany third, while England, with no change within her borders, will drop from third to fourth place.

The producing section which would be transferred from the German colors to the French has found its market chiefly in Germany, but would then have to find a new market. There is no reason to suppose that France would experience much increase in domestic consumption, and that country would therefore probably become in time a keen competitor in the export trade. In circumstances of which this illustration is one suggestion, it seems quite impossible to make guesses as to what place the American iron trade will occupy in the world's commerce after the war, while it does seem reasonable to conclude that during the war no spectacular demand for iron and steel can arise in any part of the world.

Pig Iron

The pig iron market has been stagnant. Buyers have been extremely conservative and purchases have been few. Actual consumption has decreased and shipments of merchant furnaces have been curtailed. As the producers must necessarily be conservative there has been a decrease in production, and the merchant furnace output of pig iron is the smallest for a long time, with prospects of further reduction. The price situation having already been well liquidated there have been no material declines. The eastern market has advanced a trifle and the Chicago market has lost a little ground.

Current quotations are partly nominal: No. 2 foundry, f.o.b. Birmingham, $10 to $10.25; delivered Philadelphia, $14.70 to $14.95; f.o.b. furnace, Buffalo, $13 to $13.50; f.o.b. furnace, Chicago, $13.25 to $13.50; at valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $14; basic, $13; No. 2 foundry and malleable, $13 to $13.25; gray forge, $12.50 to $12.75. Ferromanganese has weakened after the early excitement, and prompt shipments from American stocks are quoted at about $85, shipments from England in limited quantities being quoted at $80, f.o.b. Baltimore.

Steel

The large mills advanced their quotations on billets and sheet bars early in September, and have since been quoting $21 and $22 respectively. Small lots are occasionally offered by the smaller mills at somewhat lower figures, while deliveries on current contracts are also at a much lower level. In the minds of buyers at least there is serious question whether the present quoted prices will ever be the subject of extensive trading. Rods are about $26, Pittsburgh. A few sales have been made for export to England at a slightly higher level, while domestic contracts now being filled average less than $25.

Finished Steel

There have been scarcely any changes in quoted prices on finished material.

The quoted prices are not being seriously tested, as new buying is practically at a standstill, and specifications on old contracts, made before the recent advances, are materially reduced.

Prices named below are regarded as representing the market, such as it is, and f.o.b. Pittsburgh unless otherwise stated.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars and bands, 1.20c., base; steel hoops, 1.30c., base.

Iron bars, 1.25c., Pittsburgh; 1.17½c., Philadelphia; 1.07½c., Chicago.

Sheets, blue annealed, 10 gage, 1.45c.; black, 28 gage, 2.00c.; galvanized, 28 gage, 3.00c.; painted corrugated, 28 gage, 2.20c.; galvanized corrugated, 28 gage, 3.05c.

Steel pipe, ¾ in. to 3 in., 80 per cent off list.

Steel boiler tubes, 3½ in. to 4½ in., 72 per cent off list.

Wire nails, $1.60, base; smooth fence wire, 1.40c., base; galvanized fence wire, 1.80c., base; galvanized barb wire, 2.00c.

Standard railroad spikes, 1.45c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.55c.; boiler rivets, 1.65c.

Cold rolled shafting, 66 per cent off list.

Chain, ⅜ in. proof coil, 3.05c.

An alloy for welding copper and nickel, patented in this country by Canzler and Samesreuther (1,103,482) consists of copper, phosphorus and a small percentage of silver.

Light, strong castings, adapted for use where high temperatures are employed, can be made of 85 to 87 per cent aluminium, 9 to 11 per cent zinc, 2 to 4 per cent lead and 1 to 3 per cent of a strengthening element such as copper or nickel. The formula is patented by C. P. Van Gundy (1,098,137). Tellurium is suggested as a strengthening element in aluminium alloys, in patent (1,102,618) granted to Samuel Wein.

Deposits of phosphate near the Red Sea have been largely developed in the last two years, according to the Egyptian *Gazette*. The mines are worked by a British company, and the product is exported. The rock contains 65 per cent or more of tri-calcium phosphate. Other Egyptian deposits also are being exploited under concessions. The total output of phosphate rock in 1913 was a little over 100,000 tons, almost all of which came from the Red Sea deposits. Shipments are made mainly to Japan. The local demand for raw phosphate is almost negligible, and superphosphate is imported. Projects are being considered, however, for the local manufacture of superphosphate.

Program of Niagara Falls Meeting of the American Electrochemical Society

The twenty-sixth meeting of the American Electrochemical Society will be held in Niagara Falls from Oct. 1 to 3, with hotel headquarters at the Clifton Hotel.

Thursday, Oct. 1.

9:30 a. m. Reading and discussion of papers at the Clifton Hotel.

The Constancy of Base-Metal Thermocouples as Affected by Their Microstructures: O. L. Kowalke.

The Evaporator and the Power Problem in Electrochemical Plants: Otto Mantius.

On Electrometric Titrations: Henry Ziegel.

The Reproducibility of the Copper Electrode: Frederick H. Getman.

The Source of Impurities in Cathode Copper: Lawrence Addicks.

The Electrolytic Determination of Nickel: N. Judson Marsh.

Experiments on the Quantitative Determination of Radium: Herman Schlundt.

2 p. m. Excursion to Foster's Flats.

8:30. Smoker in Clifton Hotel.

Friday, Oct. 2.

9 a. m. Excursion to plants on the American side. Among those to be visited will be the power houses, the Acheson Graphite Company (who will show some features not hitherto exhibited), the Niagara Alkali Company (under usual reciprocal restrictions), Spirella Corset Company (triple-plating department), etc.

2 p. m. Reading and discussion of papers at the Clifton Hotel.

Silicidized Carbon: Silfrax: F. J. Tone.

The Electrolytic Insulation of Aluminum Wire: C. E. Skinner and L. W. Chubb.

Electro-Percussive Welding: C. E. Skinner and L. W. Chubb.

On the Formation of a Badly Conducting Film on a Copper Anode in Copper Cyanide Solution: W. Lash Miller.

Tin Salts of Mineral Acids: F. C. Mathers and B. W. Cockrum.

Electrodeposition of Lead from Lead Lactate and Lead Formate Solutions: F. C. Mathers and B. W. Cockrum.

Electrodeposition of Lead from Lead Acetate Solutions: F. C. Mathers.

7 p. m. Dinner at Clifton Hotel, to be followed by an illustrated lecture: "The Physical Nature of Color," by C. E. Kenneth Mees (director of Research Laboratory, Eastman Kodak Company).

Saturday, Oct. 3.

9:30 a. m. Symposium on "The Practical Side of Electrochemical Investigation," at the FitzGerald Laboratories (Highland and Whirlpool Avenues, Niagara Falls, N. Y.). This symposium will consist of a number of informal demonstrations of apparatus, methods, and materials used in electrochemical investigations, or as electrochemical aids to chemical investigations. The symposium will proceed throughout the day, with an intermission at 1 p. m., when a complimentary luncheon will be tendered by the Niagara Falls members at the Cliff Distributing Company's substation, Highland and Whirlpool Avenues.

In the evening there will be an informal rendezvous at the Niagara Club.

The privileges of the Niagara Falls Country Club will be extended to members throughout the meeting.

Mr. F. A. Lidbury, works manager of the Lidbury Electrochemical Company, is the president of the American Electrochemical Society

The Effect of Steam Upon Magnesite Brick or Calcined Magnesite

BY R. H. YOUNGMAN

Carbonate of magnesia or magnesite is found chiefly in Greece, Austria-Hungary, Africa, India, and in California in the United States. The deposits of Greece and California are of the white massive character and as a rule of very pure quality. They are not as suitable for refractory purposes in metallurgical processes as the Austro-Hungarian magnesite, on account of composition and high cost of preparation. The white magnesites are used principally in caustic form as flooring cement and for the manufacture of carbonic acid gas, the carbonate as mined containing approximately 50 per cent of CO_2 (carbonic acid gas) which may be driven off for this purpose at comparatively low temperature. A few refractory brick are made from white magnesite, but difficulties of manufacture and high cost render the demand very slight.

It is with the Austro-Hungarian magnesite that the users of magnesite in this country are most concerned. The material occurs in a crystalline formation and is gray in color with tinges of brown. In comparison with the white magnesite it differs in composition and formation. The chemical composition is the most important difference. Comparative analyses of the two kinds of magnesite, calcined, are as follows:

	Austro-Hungarian	White
Silica (SiO_2)	2.75	2.50
Alumina (Al_2O_3)	0.50	0.25
Iron oxide (Fe_2O_3)	7.00	1.00
Lime (CaO)	2.50	2.25
Magnesia (MgO)	87.00	93.00
Loss on ignition	0.75	1.00

The impurities in the Austro-Hungarian render it less refractory, and it will frit more readily at operating temperatures, which is a very important property, especially in open-hearth practice in building the bottom and repairing the slag line. In the calcined form, for commercial uses, Austro-Hungarian magnesite has a rich brown color and white magnesite is either white or a very light brown, depending upon the thoroughness of calcination.

The chief uses of magnesite brick are in open-hearth steel furnaces, copper converters, reverberatories and settlers, and electric furnaces. Their use is spreading considerably where strong basic slags, mill cinder and strongly metallic slags are encountered, such as the bottoms of forging, heating, and welding furnaces.

It is an interesting fact, and one of importance to all users of magnesite, that when subjected to the action of steam, magnesite in calcined form, or even the most thoroughly burned brick, will hydrate, similarly to the action of calcined lime when water is added. This hydration takes place to equal degree in all brands of magnesite brick made in the United States or Europe. The effect of the hydration is disintegration to an almost impalpable powder. It does not seem to bear any relation to the content of lime or other impurities, as the tests showed the same results for Austro-Hungarian as for white or very pure Grecian magnesite.

Tests were conducted by placing brick in a steam-tight cylinder and subjecting it to steam at 100 lb. pressure for a period of two hours, all brick tested showing hydration to the same degree, though it is reasonable to conclude that the action would be somewhat retarded under lower pressure or less severe conditions.

Difficulties of this nature have been experienced in open-hearth furnace bottoms by laying the brick and magnesite bottom over a bed of refractory materials mixed with water. Upon heating up steam is formed and the bottom may be very badly damaged by hydration of magnesite.

This fact, which has not been well established until recently, no doubt accounts for a number of similar troubles which have occurred in years past. It also explains cases of disintegration of burned magnesite brick which have been in contact with steam leaking from coils or steam-heated floors used in manufacturing magnesite brick. It should be made a matter of common knowledge, therefore, so that users of magnesite will be able to guard against trouble of this kind, especially during the initial heating period.

Harbison-Walker Refractories Co.,
Pittsburgh, Pa.

The Determination of Phosphorus in Scheelite Concentrates

BY E. W. HAGMAIER

The two most common methods for analyzing scheelite concentrates are:

Place 1 gram of the concentrate in a porcelain evaporating dish or casserole and add 75 cc of concentrated hydrochloric acid, and from time to time add potassium chlorate until the tungsten is all oxidized. This will require from 3 to 4 grams. If one does not want to use hydrochloric acid and chlorate, then aqua regia may be used, and the sample is taken to dryness. Take up with dilute hydrochloric acid (1½), warm and loosen as much of the tungstic acid from the sides as is possible. Add 15-20 cc of cinchonine solution, some paper pulp, and let stand about half an hour before filtering. Filter and wash with dilute hydrochloric acid to which some cinchonine nas been added.

The residue which is tungstic acid, silica, and some iron is burned in a platinum crucible, and then treated with a few drops of sulphuric acid and several cc of hydrofluoric acid and the silica volatilized. The excess sulphuric acid is driven off and the crucible weighed. A sodium carbonate fusion of the residue is then made and the melt is leached out of the crucible with water, and boiled. The tungsten is in solution as sodium tungstate and the iron which was held by the tungsten is precipitated as carbonate. This is filtered and washed with hot water, and burned in the original crucible, this weight deducted from the former weight gives WO_3.

In order to determine the phosphorus in these concentrates it is necessary to treat another sample as above, but omit the addition of cinchonine before filtering and in washing. The writer's experience has been that some of the tungsten washes through, necessitating a second filtration after the filtrate has been concentrated. This takes considerable time as the filtrate must again be evaporated to a low bulk after the second evaporation before the phosphorus is precipitated.

It occurred to me that the phosphorus could be precipitated from the cinchonine filtrate by using cerium chloride as a precipitant for the phosphorus.

To the cinchonine filtrate from the scheelite add 10 cc of cerium chloride solution (1 gram cerium chloride, 25 cc hydrochloric acid, 250 cc water), make the filtrate neutral with ammonium hydroxide, boil five or ten minutes, and filter, washing with hot water. Dissolve the precipitate off the paper with hot (1-1) nitric acid and precipitate the phosphorus with molybdate.

The following results were obtained on synthetic mixes with WO_3 65-70 per cent, Fe_2O_3 4-5 per cent and phosphorus 0.100, 0.150, 0.300, 0.200.

Phosphorus found	No. 1	No. 2	No. 3	No. 4
	0.083	0.152	0.296	0.195
	0.087	0.144	0.293	0.195
	0.094	0.147	0.303	0.193
	0.096	0.147	0.298	0.203

Babcock-Hagmaier Laboratories,
Lackawanna, N. Y.

Grinding Ore for Cyanidation: A Suggested Modification for All-Sliming Practice

BY W. J. PENTLAND

The following comments are intended to apply to "all-sliming" practice of crushing, and principally to the silver ores of Mexico that call for more extended treatment than do the ordinary docile gold ores of the United States.

It is common custom that the treatment of ore is controlled by what is found necessary for the satisfactory treatment of the most refractory part, even though a large part may not call for that treatment with its consequent cost.

When we follow the incoming ore through the mill, sampling and testing at each successive step, we find that a part separates easily and quickly, gives up its valuable metal with less time of contact and agitation, and often with weak solution. We find that the remaining part also separates easily and quickly, but is of denser and more compact nature, needs longer time of contact and agitation, and also needs grinding and regrinding.

This separation takes place in the classifiers that follow the primary grinders—stamps, chilean mills, or whatever type the primary grinder may be.

Different Character of Sand and Slime

The first part—the overflow from the classifier—we may call "slime." It is usually the softer and more friable part of the ore; was not made by any effect of the crushing, but was simply released; and contains but very little material that could be considered as having been made in the crushing operation. It constitutes anywhere from 30 to 60 per cent, by weight, of the total ore crushed.

The second part—the discharge from the classifier—we may call "sand." It is usually the harder and tougher part of the ore; is made up of all sizes of particles, from the finest to the coarsest that have passed through the screen; needs regrinding to bring it somewhere near the size of slime to release its valuable content; and requires longer agitation to extract the metal. It constitutes anywhere from 70 down to 40 per cent, by weight, of the total ore crushed. But even if it constitutes only 40 per cent of the total ore, the 100 per cent of the ore will be subjected to the treatment determined as necessary for this 40 per cent. Area of tanks and buildings, stronger cyanide solution, power for agitation, repairs and renewals, all have been provided and are being used on the maximum treatment basis for the total ore, when but a half or less of it requires anything like such treatment.

Special Treatment for Refractory Part of Ore

It may be argued that it would be another complication to make a separation of these two parts of the ore; but that argument would not apply, for the separation *is always made*. It is made at the classifiers; and moreover, one of the parts is always thickened for the immediately following regrinding, in fact is too thick for agitation. This is the "sand" part. It does not matter that this part may be subsequently ground to the same size as the slime; it is still sand in everything but size; it is dense and compact; and even though it may not call for stronger solution, it will call for longer time of contact and agitation. It is separated; it is thickened; it is ground to its ultimate size; and it should be given the treatment necessary for itself before it is again combined with the slime. Or rather, it should be given such separate agitation that when later combined with the slime, the strength of solution and time of contact sufficient for the treatment of the slime will also be sufficient to *complete* the treatment of the sand.

We would not recommend separate decantation, because the slime alone would be found difficult to settle readily if the sand were not combined with it to assist settlement; moreover, there would be no advantage in decanting the two parts separately as the process would be identical with each.

Agitator in Tube Mill—Classifier Circuit

The mill arrangement on this basis would place the sand agitators following the tube mills. The pulp would have to be elevated; but it has to be elevated anyway, either by some elevator, pump, or air-lift, to the classifier; or by the classifier itself and a big scoop on the tube mill, if a closed-circuit system be followed. And if it were the custom to send the pulp direct from the tube mill to the thickener, the pulp could flow into and from the agitator set at a low level, without consuming any appreciable amount of fall in addition.

In any case, the top of the agitator would be such that the overflowing pulp could flow to the classifier. The closed circuit would still be maintained; the pulp sufficiently ground would have received its due agitation and would join the overflow of slime from the classifier, and go on to the thickener. The insufficiently ground pulp would be discharged from the classifier and returned to the tube mill, again passing through the agitator.

The elevating of the pulp to the top of the agitator would not be any great addition to what is already being done, and could be accomplished easily by placing an air-lift *inside* the agitator, or in the last of a series of agitators, thereby taking care of the submergence question. Under conditions of present practice we have a classifier set close up to a tube mill, with launders running to and from it on the ragged edge of insufficient fall, and a great, big, unwieldy scoop on the head of the mill. Under the proposed scheme we might have a small, light, cheap scoop on the head of the mill, the discharge flowing by gravity directly into an agitator or a series of them, with an air-lift placed *inside* the last agitator to lift the pulp the few feet necessary to return it to the classifier. As between the two arrangements, give me the latter with the air-lift.

The depth of the agitator can be placed below the discharge of the tube mill, excavating if necessary; or the agitator can be placed in a distant part of the mill if immediate space be not available close by, the pulp elevator being placed before or after the agitator as conditions would indicate.

If the tube mill should discharge into the agitator by gravity, there would also be the advantage of the latter acting somewhat as an equalizer: if the charge were carried a few inches low, the air-lift could be stopped if the classifier had to be shut down temporarily; if the crushing also had to be stopped, the air-lift could be stopped, but the agitation could continue.

Also, but not least, if concentration were practiced, the sand would carry all the concentratable product; it would be in ideal form, thickened but easily diluted to the desired point. The air-lift at the overflow of the agitator could elevate the pulp to such height as would permit of its being passed over tables and still returned to the classifier or to the thickener as might be desired. And as most concentrating tables also classify pulp tolerably well, that sand which had been "slimed" in passing through the tube mill could be cut out and sent directly to the thickener; only the sand really needing regrinding being returned to the classifier.

Scheme Applicable to All-Sliming Method

These ideas apply to any plant making an "all-slime" product; whether using cones, Esperanza, Dorr, Akins, or any other classifier; Trent, Dorr, or any other agitator; continuous decantation as Dorr has arranged it, or as Trent works it.

With Dorr's arrangement of precipitating the overflow from the first thickener in continuous decantation, this overflow would be enriched by the metal dissolved from the agitated sand; the metal dissolved from the slime in later agitation would still go around through the batteries and ultimately be recovered from the thickener overflow solution as now arranged.

The combined pulp would still pass through the usual first thickener; but the agitators following would be designed to give only the conditions necessary to make the extraction from the slime, this being only a part of the treatment formerly given to the whole combined pulp. The sand agitators would be of capacity for only half or so of the total ore; special treatment could be given this refractory part of the ore; and the solution used on it would be substituted by new solution by the time it reached the second agitators, which of itself would be a benefit.

We believe that this suggested arrangement offers a number of possible advantages: (1) less equipment; (2) weaker solutions and lower chemical consumption of cyanide; (3) earlier recovery of valuable solution; (4) lower grade of solution to be displaced at the tail end of the plant, with consequent reduced loss of dissolved metal; (5) lower mechanical loss of cyanide, because of weaker solutions; (6) lower power consumption to the extent that the agitation in the second agitators would be only for the period found necessary to make extraction on the slime. It is true that the use of power for agitating the sand has been transferred from one set of agitators to another, but the saving lies in not agitating the slime any more than its needs demand.

Importance of Strength of Solution and Time of Contact

Strength of solution and time of contact seem to stand out as the most important factors in agitation. Volume of solution and substitution of new solution in extended time of agitation, are also factors of importance, but not to the extent of the first two.

It seems to have been determined in general practice that where strong solution and shorter time of agitation give equal results in extraction with weaker solution and longer time of agitation, the latter system is the more economical in the end. It would appear that the higher cyanide consumption due to the use of stronger solutions, with less agitation, is more costly than lower cyanide consumption due to lower strengths used, with more agitation and consequent power cost. At least that seems to be general practice; the universal tendency being to endeavor to bring about the use of lower strength solutions, even though it entail longer time of agitation. What every operator the world over is always trying to do above everything else is—reduce the strength of the working solution. He can trace most of his economies effected to this source. He can allow quite a margin in installation, power consumed, and in many other features, if he can but accomplish a lowering of the strength of his solution. A great saving is always made in the cyanide consumed chemically; solutions do not foul so easily and quickly; and the mechanical loss of cyanide is always less with weak solution as there is less to be displaced before discharging the final tailing.

If operators would consider more the mechanical losses that occur all through the plant in addition to that represented in discharged tailing, they would thereby locate a lot of the trouble experienced in making bullion recovery tally with assay returns.

If any operator takes the faith cure and persuades himself that his shift bosses do not overflow tanks and launders; do not waste solution around pumps and in pipe and valve repairs; do not permit leaks from the bottom of tanks to seep away; he will have to study advanced mathematics to enable him to figure out a method to explain away discrepancies in final results.

The weaker the strength of the working solution the less loss from all these mechanical troubles; also, the dissolved valuable metal circulating around a plant would be less, and the loss from this source would also be reduced.

Proper drainage floors leading all waste to catch basins would recover most of the loss, but how many plants do we find that have all floors cemented, and draining to catch basins?

Early Recovery of Dissolved Metal

In Dorr's arrangement of continuous decantation he does not precipitate the solution recovered after agitation, but sends it back to the batteries to serve the incoming ore first, and then precipitates it when recovered from the overflow of the first thickener. This is evidently a point evolved to recover the valuable solution as early as possible in the system so that there will be less of dissolved metal to be carried toward the tail end of the plant; and he thereby relieves the decantation tanks of a great part of their most responsible work. At the same time he is putting more dissolved metal into circulation around the plant, and this is subject to the mechanical losses that we have been emphasizing.

With agitation of the sand after regrinding and before thickening, the metal dissolved from this part would be recovered from the overflow of the thickener immediately following. There would, therefore, be no circulating around the plant of this part of the dissolved metal; also, the dissolved metal carried with the pulp from the second agitators to the washing thickeners would be less than ever, with consequent reduction of dissolved metal in the tailing.

The sand being the more refractory, the cyanide for strengthening solution would be added to the head of the tube mill, thus making the tube mill a part of the sand agitating system. This stronger solution would raise considerably the strength of the battery solution that really constitutes the overflow of the first thickener. In all probability this solution accompanying the thickener discharge would still have an excess of cyanide for effecting extraction on the slime. Hence no cyanide would have to be added to the second agitators; weaker solution would be circulating toward the tail end of the plant; and mechanical loss from this source would be reduced.

Another feature that supports this last contention is, that the strengthening of the battery solution in the classifier by the strong solution coming over with the agitated sand, would raise the strength of working solution in contact with the slime while passing through the classifier and the thickener. This would occasion earlier dissolution of metal from the slime, further enrich the thickener overflow and thereby earlier remove more metal from circulation. It would also reduce the work required of the second agitators, and so more than ever reduce the cyanide and dissolved metal to be taken care of at the tail end of the plant.

It may be contended that but few ores are of such a nature that the part we designate as slime would give up its valuable metal under the conditions that we

specify. It is a matter of interest that in the Black Hills of South Dakota there are plants operating in which the slime separated at the classifiers is passed through thickeners serving as continuous wash tanks, and *no specific agitation at all* is given this pulp. It gets its agitation while passing through the crushing apparatus. It is of no especial concern at the moment that these Black Hills operators have percolation plants to treat what we here call the "sand" part of the ore. If they should later practice all-sliming they would still separate this same sand as they are now doing, could give it its due agitation apart, and then combine it with the slime and carry out the same treatment that they are now giving the slime.

Scheme Applicable to New or Existing Plants

The application of this system would present no particular difficulties. In designing a new plant we would have everything more compact and more easily supervised, as the sand agitators and the first thickener would be about on the same level, and close to the tube mills instead of two levels below. Heretofore we have had to concede to the thickener's particular service the fall or depth of its tank, and all the subsequent equipment has had to come below it to make a gravity-flow plant. It is true that with Dorr's arrangement the zinc boxes now come practically on the thickener level or but little below. With our scheme the sand agitators, thickener, and zinc boxes would all come on practically the same level. Below this level would come the combination agitators, and the thickener wash-tanks.

In adding these sand agitators to an existing plant they would have to be placed wherever a location could be found, even at a distance; and it is likely that more elevation would have to be given the pulp, as the distance to and from the agitators would have to be considered in determining the fall of the carrying launders.

This separate agitation of the sand does not involve the use of any particular crushing machinery, the use of any particular classifier, thickener, or agitator, nor the use of any particular decantation or washing system. It would serve only with "all-slime" crushing.

Denver, Colo.

The mineral production of Texas for 1913 is valued by the U. S. Geological Survey at over thirty million dollars. The state ranks nineteenth among the United States in the value of its mineral production. It ranks second in the production of asphalt and third in production of quicksilver. It holds fourth rank in quantity of petroleum produced. Sulphur production, by methods similar to those used at Sulphur City, La., were begun at Bryan Heights, in Brazoria county, in 1913.

Imports of artificial dye-stuffs into the United States have been valued at $10,000,000 annually for each of the past five years. The imports for the year ending June 30, 1914, fell off about 5 per cent in value as compared with previous years. The following table shows the imports for 1914, with the share furnished by Germany.

	Pounds	Value
Alizarin and alizarin colors:		
From Germany	2,593,758	$833,705
From all other countries	39,656	11,754
Aniline salts:		
From Germany	2,768,191	202,722
From all other countries	316,276	20,006
Indigo:		
From Germany	7,448,412	938,097
From all other countries	676,799	155,129
Coal-tar colors, all other:		
From Germany	.....	5,965,537
From all other countries	.....	1,275,869
Total values:		
From Germany		$7,940,061
From all other countries		1,462,758

NOTE.—The statistics for indigo include imports of natural indigo from India, which average less than $100,000 worth annually.

The Possibilities of Hardwood Distillation on the Pacific Coast

BY R. C. PALMER

Chemist in Forest Products.

Forest Products Laboratory, Madison, Wis.

Introduction

The interest in the wood distillation industry on the Pacific Coast has been confined in the past entirely to the softwoods, Douglas fir, and western yellow pine. Unfortunately, the history of the commercial attempts that have been made to obtain valuable products for these species has been largely a succession of failures, owing to a variety of causes.

The fact that softwood distillation is not a well established industry, the inability to secure commercial quantities of suitable raw material at favorable prices, and the more or less experimental nature of plants that have been erected have been in general the main causes for these failures. The products which these plants attempted to recover from the western softwoods were turpentine, tar, tar oils, and charcoal, and in several cases alcohol and acetate of lime, depending on the process employed.

It is well known that the yields of the three last named products, charcoal, alcohol, and acetate, are considerably less from softwoods than from hardwoods, and that the yield of these products is sufficient to make the distillation of certain species of hardwood a perfectly feasible commercial enterprise.

In view of the importance to other industries on the Pacific Coast, of securing wood-distillation products, particularly charcoal and wood alcohol, without paying freight from plants in the middle western or eastern States, and because of the very limited possibilities of securing these products economically from softwoods, the United States Forest Service conducted investigations during the fall and winter, 1913-14, both at the Forest Products Laboratory, Madison, Wis., and on the coast, to study the feasibility of establishing a small hardwood distillation industry in that locality.

The results of this investigation are summarized in this paper.

Hardwoods Available

There is a large variety of hardwoods native to the Pacific Coast, including birches, maples, and oaks. There are some fifteen species of oaks alone, besides several imported species such as Eucalyptus, acacias, madrone, etc.

None of the native hardwoods occur in pure stands, however, and very few in large enough stands mixed with the softwoods to make them of importance as raw material for a distillation plant.

From the standpoint of the species with quantities sufficiently centralized only two or three appear promising: (1) the tanbark oak (Quercus densiflora); (2) the California black oak (Quercus Californica), with the scattering "white oaks"* that occur with it—such as Oregon post oak, Chinquapin oak, Canyon live oak; (3) possibly Eucalyptus.

The present investigation has considered only the tanbark oak and the black oaks. It seems probable that Eucalyptus will compare favorably with the oaks as regards yields of by-products, but the quantities available are too small to be considered for the present. Eucalyptus gives an especially high grade charcoal which brings a high price per ton in limited quantities and can, there-

*These oaks occuring in scattered stands as well as a number of hardwoods such as gray birch, Oregon maple, alder, cottonwood, etc., probably all have a value for making charcoal alone where few charcoal kilns can supply the immediate demands of a community. Since softwoods can compete with the hardwoods in the manufacturing of charcoal alone, these hardwoods are obviously eliminated from the list of possibilities.

fore, be best considered only for the production of charcoal.

Tanbark Oak

Tanbark oak is best known because of the high value of its bark for the production of tannin. However, only the bark is used, and the tree is generally allowed to rot in the woods. Utilizing the wood of this tree after being abandoned by the bark peelers is an economic problem of considerable importance.

This oak occurs principally in the redwood* belts of Mendocino and Humboldt counties, California, forming a band along the inland side of the redwood covering what is called the "Bald Hills." The best stands are not in the main redwood forests, but only on the summits above the redwood, particularly on the inner summits and ridges. Here the trees are most abundant and of large size and running probably as high as 15 to 20 cords of wood per acre; with an average of about 7 to 10 cords.† This stand is light compared to the usual yields of cordwood per acre for distillation plants, but as this same region will be logged for the great redwood forests, there is a possibility of securing the tanbark wood in connection with these logging operations.

The logical place for distillation plants using the tanbark oak is in connection with the redwood lumber mills cutting in this region, and where mills are in the coast towns, thus providing shipping facilities for the products either by rail or water.

California Black Oak

The California black oak occurs in a much more solid stand than the tanbark oak. The range of this oak is comparatively wide, but the accessible timber is located in a small area of about 40 square miles in Shasta County, California, north and west of the Pitt River, and along its tributaries. This oak occurs in largest quantities on the west slopes and flats of the foothills west of the Sierra Nevada range. It is estimated that in a small area beginning witih Reynolds Basin in the Shasta National Forest, where the stand will average 25 cords per acre, south and west for about 20 miles between the Pitt River and Squaw Creek, there are 300,000 cords of this oak. The black oak would make practically no saw timber, and only very scattered stands of western yellow pine and red and white fir are found with the oak. This species of hardwood from the standpoint of quantity and general characteristics would be available to a distillation plant located at a point on the Pitt River most accessible to the Portland division of the Southern Pacific Railroad.

Laboratory Tests on Tanbark and Black Oaks

Tests to determine the yields of products from California tanbark and black oaks compared to the species commonly used for distillation purposes, beech, birch, and maple, were made at the Forest Products Laboratory. The results of these tests are given in Table 1.

The yields of wood alcohol, acetate of lime, and charcoal from Douglas fir and western yellow pine are also given for comparison.

From the figures given in the table the average yields from beech, birch, and maple are about 1050 pounds charcoal, 192 pounds acetate, and 10.6 gallons crude alcohol per cord. On this basis the tanbark oak would be expected to yield about the same in charcoal, 20 per cent. more acetate, and 8 per cent more alcohol than the species commonly used.

Small trunks of black oak high in sap would give about 5 per cent more charcoal, the same acetate, and 11 per cent less alcohol than the standard species. It is apparent that for the black oak the greater the per cent of sapwood such as in limbs, the higher the yields, since small limbs* give 30 per cent greater yields in charcoal, 40 per cent greater yields in acetate, and 18 per cent more alcohol than beech, birch, and maple. The possibility of securing all black oak as limbs or other forms high in proportion of sapwood would, however, not be great.

From the laboratory tests, therefore, both the tanbark and black oaks, especially the former, compare very favorably with the species or hardwood used in other localities.

TABLE I—COMPARATIVE YIELDS OF WOOD ALCOHOL, ACETATE OF LIME, AND CHARCOAL, PER CORD* BASED ON LABORATORY TESTS†

Species	Charcoal	Acetate of Lime	Crude (82%) Wood Alcohol
	Pounds	Pounds	Gallons
Beech	1100	185 (Heartwood)††	12 (Heart)
		200 (Slabs)	11 (Slabs)
Birch	1000	205 (Heart)	9 (Heart)
		213 (Slabs)	9 (Slabs)
Maple	1050	183 (Heart)	11 (Heart)
		170 (Slabs)	11.6 (Slabs)
Tanbark oak	1050	238 (Heart)	11.4 (Heart)
Black oak	1100 (Slabs)	190 (Slabs having high per cent sapwood)	9.4 (Slabs having high per cent sapwood)
	1400 (Limbs)	270 (Limbs all sapwood)	12.4 (Limbs)
Douglas fir	800 to 900	60 Stumps	3 Stumps
		80 Slabs	4.3 Slabs
Western yellow pine	750 to 850	60 to 80	2 to 4

*One cord is taken as 90 cubic feet of solid wood containing 15% moisture.
†Results are average of several distillations, each distillation on about 80 pounds of wood.
††In a number of species it has been found that the higher the proportion of sapwood the higher the yields of acetate of lime. For this reason the different forms of wood are given.

From the laboratory tests on black oak were followed by a commercial distillation of 7 cords at the wood distillation plant of the Noble Electric Steel Company, Heroult, California. This plant was not designed for hardwood distillation, but had previously operated on western yellow pine with practically no success.

Unfortunately the plant was not especially fitted for the best results from hardwood distillation and the black oak tested consisted of split cordwood from large trees and contained practically no limb wood or forms high in proportion of sapwood.† The commercial yields obtained are given in Table II. The yields per cord from one test (2 cords) of a mixture of scrub oaks and canyon live oak classed as "white oak" are also given.

TABLE II—YIELDS PER CORD COMMERCIAL DISTILLATION OF CALIFORNIA BLACK OAK

Species	Alcohol, Crude, 82%	Gray Acetate of Lime	Charcoal
	Gallons	Pounds	Pounds
Black oak	8.7	147	1140
White oak	8.7	135	1090

The commercial yields on black oak indicated about the same charcoal, 8 per cent less alcohol, and 23 per cent less acetate of lime than the laboratory tests. These data are, however, not strictly comparable because of the difference in the character of the wood tested in the laboratory, and in the plant.

In spite of lower yields obtained commercially than was expected, the possibilities of commercial operation

*Forest Service Bulletin 75 "California Tanbark Oak."
†According to estimates in Forest Service Bulletin 75, the total stand is about 675,000,000 board feet, which would be at least 500,000 cords of wood suitable for distillation.

*These figures are based on cords of equal volume of solid wood. In actual practice a stacked cord of limbs would contain much less volume than split wood which would reduce these proportions.
†In addition to difference in form the commercial wood was either very green or badly water soaked at the time of making the tests.

are favorable, even if better yields are not obtained with better wood and plant conditions.

General Commercial Conditions

QUANTITY OF RAW MATERIAL

The possibilities of establishing a hardwood distillation industry on the Pacific Coast must be confined to fairly large and well concentrated blocks of timber suitable for cordwood. The destructive distillation of hardwoods for the manufacture of charcoal, wood alcohol, and acetate of lime, is a highly technical industry requiring rather expensive equipment of a standard design. For this reason, sufficient raw material should be available to insure 15 to 20 years life of a plant.

A plant with a capacity of 36 cords per day is about as small as can be economically operated. This would require a stand of hardwood containing from 150,000 to 225,000 cords of wood and, in addition, it is evident that the material cannot be scattered over too wide an area.

COST OF BUILDING AND OPERATING ECONOMIC PLANTS

The cost of building and equipping efficient hardwood distillation plants would be from $2,500 to $3,000 per cord per day capacity. A 36-cord plant would, therefore, cost between $90,000 and $110,000.

This applies to the standard oven type of plant in which each oven or retort holds from six to eight cords and the wood is carried in small cars, each carrying about two cords. Such a plant would be completely equipped to manufacture gray acetate of lime and wood alcohol suitable for denaturing grain alcohol.

On account of the wide variation in cost of labor, freight rates, etc., in different localities, and because of different conditions of efficiency or supervision, etc., cost data on the operation of hardwood distillation plants cannot be given which will apply to all cases.

The relative weights of the different items of the cost of operating plants are, roughly, as follows:

Raw material (wood in retorts)	40 to 50 per cent of total cost
Labor	15 " 25 " " " " "
Fuel for distilling and refining	10 " 20 " " " " "
Maintenance (repairs overhead, etc.)	15 " 25 " " " " "

The raw material is by far the largest single item of expense and especial attention to economical handling of wood is, of course, essential. Every time a cord of wood is handled it adds about $0.50 to its cost. The average cost of wood in plants in the Middle West and East is about $3.50 per cord in the retorts. The wood on the Pacific Coast would probably cost more than this as (1) it is generally less accessible, (2) it is not as well concentrated, and (3) the cost of labor is higher. Where eastern labor costs $1.75 per day, the same labor will cost $2.25 per day in California.

The choice of fuel for distilling the wood and refining the products is an important consideration. Probably the best condition as regards fuel is in case the plant is operated in connection with a saw mill where ample wood waste is available for this purpose which would otherwise be sent to the trash burner. The cost of fuel is then only the cost of conveying the waste to the retorts and maintaining the fire in the fire boxes. This cost should not be over $1 per cord of wood distilled. Where wood waste is not available in California, crude oil is probably the best fuel. The cost per cord would be, however, appreciably higher than wood waste fuel, costing probably from $1.25 to $1.50. These fuel costs are not much higher than in other places using comparable fuels.

In spite of the increase in cost of operation due to higher labor and wood costs in California over other localities the total cost of operation should apparently not be over $9.50 per cord as compared to about $8 to $8.50 per cord in other localities.

VALUE OF PRODUCTS

Higher costs of operation combined with lower yields of products as in the case of black oak would appear to be too great a handicap for profitable operation on this species of wood, but while the yields of alcohol and acetate from black oak may be somewhat lower than from beech, birch, and maple, the charcoal is slightly higher, and in addition charcoal is generally worth from 40 to 60 per cent more in California than in the localities where the charcoal from the standard distillation species is sold.

The effect of this difference in charcoal value in bringing up the total income from products is seen in the following calculation:

YIELDS FROM BEECH BIRCH, AND MAPLE, AND VALUE OF PRODUCTS IN EASTERN STATES AT PRESENT TIME

10.5 gal. 82% alcohol at 26c	= $ 2.73	or 8¼ gal. 95% at 47	= $ 3.87
195 lb. acetate at 1.5c	= 2.92		= 2.92
1050 lb. charcoal at $7 per ton	= 3.67		= 3.67
Total	$9.32		$10.46

YIELDS FROM BLACK OAK AND VALUE OF PRODUCTS IN CALIFORNIA

8.7 gal. 82% alcohol at 26c	= $ 2.26	or 6.75 gal. 95% at 47c	= $ 3.17
147 lb. acetate at 1.5c	= 2.20		= 2.20
1140 lb. charcoal at $10 per ton	= 5.70		= 5.70
Total	$10.16		$11.07

In the case of tanbark oak there is every reason to believe that the yields of alcohol and acetate will be greater rather than lower than beech, birch, and maple.

Ten dollars a ton is a minimum figure for charcoal when sold for domestic fuel in coast states. Its average value is probably nearer $15 a ton for this purpose. The market value of alcohol and acetate cannot be expected to be higher than in other localities since the same markets are supplied in both cases.

MARKET FOR PRODUCTS

Charcoal.—The possibilities of creating a demand for charcoal for domestic fuel are apparently excellent, especially in California, where both wood and coal are very high. In other localities where the manufacturer has done a little advertising, charcoal has supplanted wood blocks and kindling wood for making quick hot fires.

With the development of metallurgical processes another large market may be created for charcoal, although for this purpose the value is generally less than for domestic fuel.

Charcoal is difficult to ship for long distances, so the markets will necessarily always have to be somewhat local.

Acetate of Lime and Alcohol.—There is at present no acetate of lime used on the Coast, but home production of acetate might encourage the establishment of a small acetic acid industry to supply the white lead manufacturers.

The total consumption of wood alcohol on the Pacific Coast is at present about 1200 barrels or 60,000 gallons. A small part of this is consumed in wholesale drug houses but the largest proportion is used for the denaturing of grain alcohol. This alcohol is at present being supplied from eastern plants at 8 cents freight cost over New York quotation. There seems to be little doubt but that any plant in California could successfully compete in this home market.

With the opening of the Panama Canal the largest opportunity for marketing both alcohol and acetate of lime is with the export trade.

The following tables, taken in part from the yearly report of the U. S. Bureau of Foreign and Domestic Commerce, 1912, show the exports of these products to various countries from the United States for several years past:

EXPORTS OF ALCOHOL (GALLONS)

Country	1908	1909	1910	1911	1912	1913
Japan	280	2,350	49,829	36,490	50,302	.....
Canada	.....	209	4,539	2,486	30,799	.....
Germany	781,000	568,000	654,000	974,000	815,000	.....
Netherlands	45,000	.....	173,000	471,000	102,000	.....
All Europe	1,937,000	1,085,000	1,269,000	1,912,000	1,474,000	1,837,000

EXPORTS OF GRAY ACETATE OF LIME (POUNDS)

Country	1908	1909	1910	1911	1912	1913
Japan	.....	2,200,000	3,600,000	5,800,000	5,300,000	.....
Belgium	26,200,000	25,800,000	27,100,000	22,900,000	28,100,000	.....
Germany	17,200,000	18,800,000	14,900,000	16,700,000	16,700,000	.....
Netherlands	10,800,000	11,600,000	10,500,000	15,300,000	11,500,000	.....
United Kingdom	2,100,000	1,700,000	1,800,000	2,800,000	600,000	.....
Canada	50	241,000	15,000	.....	126,000	.....
Total	.....	66,550,000	63,687,000	70,191,000	69,235,000	80,597,000

Japan probably offers the best opportunity for export trade for wood alcohol. The wood alcohol consumption is, however, rather small. At present both these products go to Japan via the Suez Canal. Eastern plants will, no doubt, compete in this market through Panama, but in that case the European markets will be as open to any plant in California as the Japanese markets will be accessible to plants in Michigan or Pennsylvania.

A 36-cord plant would produce in a 300-day year, approximately 75,000 gal. of 95 per cent alcohol, and between 1½ and 2 million lb. of gray acetate.

From the standpoint of the present market conditions it is doubtful, therefore, if the establishing of more than one or two small plants in California would be advisable.

Lead sheets and pipes of American manufacture are in demand in European countries, according to the *Daily Trade and Consular Reports* issued by the Department of Commerce at Washington. Drawn steel tubes and lap-welded tubes of iron or steel also are needed.

A copper-leaching plant of 20-tons daily capacity is reported to have been placed in operation at the Mason Valley smelter, at Thompson, Nevada, for the treatment of certain oxidized ores from the Yerington district.

Flotation of copper ores according to a new process attributed to John D. Fields is to be tested at the mill of the Ohio Copper Co., at Lark, Utah, and at some other copper concentrators.

"Salting" of Radium Ore.—One or two instances have recently come to light in which it is thought that an attempt was made to give a fictitious radium value to uranium-bearing material. Suspicion exists that uranium residues from which radium has been extracted, have been mixed with carnotite, thereby raising the grade of the material as to uranium, so that when the radium value of the ore was determined from its uranium content, as has been customary, it would appear much higher than it is. The possibility of deception by this practice may result in abandoning the indirect determination of radium in favor on the more accurate and direct electroscopic measurement.

Diamonds have become a drug on the market since the European war broke out. The Diamond Syndicate has terminated its contract with the De Beers company in South Africa, and the mines of the latter have been closed.

Indeterminate Cases in Mixing Ores for Calculation of Furnace Charges

BY REGIS CHAUVENET

Mixing Ores to Secure a Required Percentage of Any Constituent

Before taking up the actual calculation for slag composition in a mixture of several ores, it may be well to show how to mix ores of given composition in order to secure a certain (required) percentage of any given constituent.

First, let there be two ores; the problem is so simple that it hardly requires elucidation. The requirement is easily formulated and the formula reduced to the following rule, viz.:

Take weights of the two ores in inverse ratio to the differences between their assays and the (required) assay of the mixture.

Example. (*a*). Mix two ores containing, respectively, 40 per cent and 8 per cent of a given constituent, so that the mixture shall contain 16 per cent.

(1) The larger per cent less the required per cent is $40 - 16 = 24$.

(2) The required less the smaller per cent is $16 - 8 = 8$.

Now take weights of the two ores *inversely* as these figures, i.e., take eight parts of No. 1 and twenty-four parts of No. 2. (In this instance reducing to simpler ratio, as $8:24 = 1:3$, take one part of No. 1 and three parts of No. 2.)

Proof. 100 lb. of No. 1 contains.....40 lb. metal
300 lb. of No. 2 contains.....24 lb. metal

400 lb. mixture contains.....64 lb. metal.

Then 64 is 16 per cent of 400, as required.

If there are three ores to be mixed there is no definite solution, unless one of the three happens to contain the given constituents in just the required proportion. In that case it is evident that the proper proportions of the other two ores having been adjusted, any weight whatever added of the third ore will not change the percentage of the given metal.

However, if no one of the three contains the required percentage, then if Nos. 1, 2 and 3 represent respectively the minimum, intermediate and maximum percentages, and since the required percentage must obviously be greater than in No. 1 and less than in No. 3, we have an "indeterminate" mixing problem, *"if all three ores are to be used.* For the required percentage must lie either between Nos. 1 and 2 or between 2 and 3, so that it can never be necessary to use all three ores, so far as the mere obtaining of this percentage is concerned.

By limiting the weights of one lot of ore to a certain figure, or by stipulating a certain proportion as between certain classes of ore, we may reduce the problem to a "determinate" one. Cases of this kind are exceptional, but it is well to have a ready method for figuring on them.

Example. (*b*) We have three ores assaying 39, 24 and 8 respectively. (N. B. It makes no difference whether the figures represent percentages or ounces to the ton.) We want 16 (per cent or ounces) in mixture. Obviously this may be obtained either from Nos. 1 and 3 or from Nos. 2 and 3. But suppose we are compelled to use both 1 and 2 and the latter in twice the proportion of the first.

What proportions of the three ores in the mixture? Take 100 lb. of No. 1 as the basis.

---

[1]Calculation of Furnace Charges, by Regis Chauvenet. This Journal, Jan., Feb., Mar., Apr., and June, 1912.
[2]Ibid.

100 lb. of No. 1 contains	39
200 lb. of No. 2 contains	48
300 lb. of mixture contains	87

The mixture then contains $\frac{87 \times 100}{300} = 29$ per cent or ounces. The mixture now constitutes one element of the calculation, and we proceed to mix it with enough of No. 3 to get the final required figure (16).

$$29 - 16 = 13 \text{ and } 16 - 8 = 8.$$

We have then to take 8 units of the "mix" and 13 units of No. 3.

Suppose we have to make up an "even" weight of the total mixture. Go back to original ore parts, and proportionate to (say) 1000. We find for the three required parts in 1000 lb., No. 1, 127; No. 2, 254, and No. 3, 619 lb. This may be proved as in the former example, ex. gr.

$127 \times 0.39 = 49.53$	
$254 \times 0.24 = 60.96$	
$619 \times 0.08 = 49.52$	160 is 16 per cent of 1000.
1000 — 160.01	

Mixing Ores for a Definite Slag

These little "mixing" cases are thrown in here merely as incidental to cases of mixing ores for a definite slag. We have shown an "equation" method in previous articles,[1] for any two ores and a limestone, illustrating that unless the problem is impossible for sheer lack of proper constituents in the data, it presents no especial difficulty. We now put the case of three ores and a limestone. The latter is assumed in all the examples to contain:

Silica .....10 per cent
Lime (CaO) .....50 per cent

As this is intended for an arithmetical illustration only, we simplify it by making the supposed analyses ideal to an extent not to be expected in nature. The ores are supposed to have been "cleared" of the matte, i.e., that has been taken out (by calculation) and nothing is given in the analyses except what enters the slag.

An indeterminate case is one in which several mixtures may bring about the required condition i.e., a slag of the stipulated composition.

Generally, any problem to which there are several answers, or an indefinite number of answers, may be called indeterminate.

Algebraically, an equation with two unknown quantities (x and y) with no further condition or equation to assist, is called indeterminate. The same term may be applied to two equations involving three unknown quantities, or, in short, to any set of equations presenting a greater number of unknowns than there are equations.

There are cases in which although but one rational answer is possible the statement is nevertheless indeterminate in form. These are not considered. They could hardly occur in metallurgical practice. Discussion of a few cases in which several mixes alike meet the general requirement, will be sufficient. In accordance with our precedents, there are made extremely simple.

Example. (a) We have three ores analyzing, as to slagging constituents, as follows:

	SiO_2	Bases	Lime (CaO)	
Ore No. 1	50	30	..	per cent
Ore No. 2	40	20	..	" "
Ore No. 3	30	10	..	" "
(Limestone as above)	10	..	50	" "

Ore charge is to be 1000 lb. Requirement for the slag as below, viz:

Silica	50 per cent
Bases from the ore mixture	25 " "
CaO from the limestone	25 " "
	100 " "

(We drop our usual practice of assuming 100 lb. *for one of the ores.* Note that the charge of 1000 lb. does not here include the flux (limestone).

As no one ore is fixed in weight, but the sum total of the three alone is a fixity, the weight of any one becomes an "unknown."

Let $100x$, $100y$ and $100v$ represent respectively the weights in pounds of ores 1, 2, 3 and of the limestone. The last ($100v$) is inserted to give generality in form since v may be determined without formal calculation.

The constituents are now represented by the same figures as their respective percentages, all with the unknown letters annexed, as below. (Reason for taking $100x$, etc., instead of x is to obviate necessity of fractions. Coefficients for x, y and z are now taken directly from table of analyses.)

	SiO_2	Bases	CaO
No. 1	$50x$	$30x$	...
No. 2	$40y$	$20y$	...
No. 3	$30z$	$10z$	...
Limestone	$10v$	...	$50v$

This method of setting forth the constituents entering into a slag calculation has been given at length in this journal in former articles.[2] It suffices to call attention to the fact that we may now select expressions for silica, base or lime directly from the analyses as written above, i.e., with the respective letters annexed, remembering that the total quantity of any one constituent of the charge is represented by $100x$, etc., as stated above.

There are three equations on the conditions.

$100x + 100y + 100z = 1000$ (Or; $x + y + z = 10$) (1)
$30x + 20y + 10z = 50v$ (i.e., bases = CaO) (2)
$50x + 40y + 30z + 10v = 30x + 20y + 10z + 50v$ (3)

Equation (3) expresses the condition that the silica equals all the bases, lime included. No. 3 reduces to $x + y + z = 2v$.

Hence by (1) $2v = 10$ and $v = 5$. Limestone therefore ($100v$) = 500 lb.

Quantity of Lime Independent of Proportions of the Three Ores

This shows that the lime addition is independent of the proportions of the three ores. This is no general proposition for similar cases, but merely an incident in the present conditions. It often happens, however, that some fact like the above (viz: independence of the lime addition) is first discovered analytically.

The limestone being thus found to be the same for any possible mixture under the conditions, reduce the remaining equations. We find:

(a) $x = 5 + z$ and (b) $y = 5 - 2z$

Here is the "indeterminate" condition, viz: two equations with three unknown quantities. Algebraically, this indicates an indefinite number of correct solutions. In fact, it is a case in which the two unknowns in these final equations become variables. Assume a value for one of them, the other must, of course, assume a corresponding value. Discussion of the maximum and minimum values of each of these unknowns is exceedingly simple. As z occurs in both of the equations, let us start with it.

(a) shows that 0 is a possible value of z (minimum).

(b) shows that with $y = 0$, z has its maximum value of 2.5

Substituting in (a) we find x has a maximum value of 7.5 and a minimum value of 5. (That is, the ore No. 1 may run from 750 down to 500 lb., but not less.)

Substiuting in (b), we find that y has a maximum value of 5, minimum of 0. We could eliminate z, getting $2x + y = 15$. Then $y = 0$ makes $x = 7.5$, and any value for x less than 5 violates the data. But this would save no time, as z would have to be brought in again.

Tabulating these various cases, and writing the values multiplied by 100 so as to represent actual pounds of ore or flux, we have

	Maximum	Minimum
Ore No. 1, lb.....	750	500
Ore No. 2, lb.....	500	0
Ore No. 3, lb.....	250	0

(*Limestone, always 500 lb. for any mixture.*)

We see, then, that ore No. 1 must always be used, and with it, some portion of No. 2 or No. 3 or both, according to the weight of No. 1 taken. Any violation of the equations violates also the slag condition, as may easily be shown.

Take maximum of No. 1; No. 2 now goes to its minimum, i.e., zero. But No. 3 goes to its maximum, 250 lb.

Take minimum of No. 1; No. 3 now goes to its minimum (zero), while No. 2 goes to its maximum, 500.

In all other cases, viz.: with No. 1 somewhere between maximum and minimum, all three of the ores enter the mixture. Assume any value between limits for x then substitution in equations (2) and (3) gives values to y and z.

Examples under each case.

(*a*) Ore No. 1: take maximum weight of same. Calculate bases and silica. (No. 1 = 750 lb.; No. 2 = 0; No. 3 = 250 lb.; total = 1000 lb.)

	SiO_2	Bases	CaO	
From ore No. 1.....	375	225	...	lb.
From ore No. 2.....	0	0	...	"
From ore No. 3.....	75	25	...	"
Limestone	50	...	250	"
	500	250	250	"

(*b*) Ore No. 1: take minimum weight.
No. 1, 500 lb.; No. 2, 500 lb.; No. 3, zero.

	SiO_2	Bases	CaO	
From ore No. 1.....	250	150	...	lb.
From ore No. 2.....	0	0	...	"
From ore No. 3.....	0	0	...	"
From limestone	50	...	250	"
	500	250	250	"

(*c*) Ore No. 1; take *any weight intermediate* the maximum and minimum.

No. 1, 700 lb.; No. 2, 100 lb.; No. 3, 200 lb. These figures are found by substituting in (a) and (b).

	SiO_2	Bases	CaO	
From No. 1.....	350	210	...	lb.
From No. 2.....	40	20	...	"
From No. 3.....	60	20	...	"
From limestone	50	...	250	"
	500	250	250	"

In the last case we assumed, arbitrarily, that we should take 700 lb. of No. 1. But as this figure is between the limits (750 maximum and 500 minimum) it must lead to correct results under the conditions. Note that these conditions are satisfied in every case—i.e., silica always equal to bases, and CaO always equal to bases from the ores. The problem is thus reduced to finding maximum or minimum weight which can be used of three given ores. It could be used to increase or decrease the use of certain ores, according to supply or cost.

Novices in algebraic statement often attempt to get as many equations as there are unknown quantities, in an indeterminate case. For instance, another equation which in reduced form would read:

$$5x + 4y + 3z = 45$$

could be taken to represent the condition that silica = twice CaO. But this is already implied in the equations above, so that in eliminating x we merely regain the old form: $y = 5 - 2z$.

Calculation Based on Assumption of One Hundred Pounds of Principal Ore

In calculating furnace charges for slags, we prefer to assume 100 lb. for the leading ore, and adjust the other additions to that figure. Texts on slag calculation differ in this respect; there are those who seem to prefer an assumption for *weight of total charge* (i.e., all the ores and fluxes, but not including the fuel).

In the following example we adopt the method that has always seemed both easier and more logical to us. It is, of course, a mere matter of convention. But it is such an easy matter, having figured for the 100-lb. basis, to pass to any other basis, that the method assuming total charge for the basis of calculation is no longer in favor.

If in any calculation of this kind a value with minus sign should be obtained it is, aside from errors of computation, an indication of the fact that you are attempting to reconcile incompatibles. Inspection of analyses will often show in advance that no mixture of the given components can give the desired result.

To illustrate the above, take the following case: We have three ores with analyses of slagging constituents annexed as below:

	Silica	FeO	Other bases
Ore No. 1.....	40	10	30 per cent
Ore No. 2.....	10	60	10 " "
Ore No. 3.....	20	10	40 " "

Assuming that these can be mixed for "self-fluxing," i.e., without the addition of any limestone, we demand a slag of the following composition, viz.:

Silica, 40 per cent. Iron oxide (FeO), 35 per cent. Other bases, 25 per cent.

As basis for the ore mixture, take 100 lb. of No. 1 ore. Let quantities of ores Nos. 2 and 3 be represented by $100x$ and $100y$ respectively.

We have now as expressions for constituent parts the following:

For SiO_2; $40 + 10x + 20y$
For FeO ; $10 + 60x + 10y$
For base; $30 + 10x + 40y$

The 40, 35, and 25 required percentages reduce to ratio 8, 7 and 5.

$7(40 + 10x + 20y) = 8(10 + 60x + 10y)$
Ratio of SiO_2 to FeO.

$5(10 + 60x + 10y) = 7(30 + 10x + 40y)$
Ratio of FeO to bases.

The equations present no difficulties in elimination, but having solved for x, which we find = 0.45 +, we find on substituting that *y comes out minus.*

Inspection of the analyses, in fact, shows that there is so much iron oxide in No. 2 ($100x$) that we cannot simultaneously get iron low enough and base high enough, while No. 3 ($100y$) has so high a base that it upsets all attempts to adjust the three to the requirements. A trial of any two of the ores will show that the condition is incompatible with the composition.

Example (*b*). We give another example of the "indeterminate." The limestone, as indicated in the first place, remains the same, viz.: SiO_2 = 10 per cent, CaO = 50 per cent.

	SiO_2	FeO
Ore No. 1	40	10 per cent
Ore No. 2	30	20 " "
Ore No. 3	10	30 " "

Calculate in this case, the ore charge on the basis of 100 lb. taken of No. 1. *Slag to have composition:* $SiO_2 = 30$ per cent, FeO = 40 per cent and CaO = 30 per cent; the latter, of course, has to come entirely from the limestone. As before, let $100x$ = lb. of No. 2 ore, $100y$ = lb. of No. 3 ore, and $100z$ = lb. of limestone. Collect expressions for SiO_2, FeO and CaO as usual, and equate according to the slag condition.

We cannot obtain more than two independent equations. A few paragraphs back we said that novices often try to get as many equations as there are unknown quantities. Let us try here. We have:

$$\text{Total } SiO_2 = 40 + 30x + 10y + 10z$$
$$\text{Total FeO} = 10 + 20x + 30y$$
$$\text{Total CaO} = 50z$$

Since silica is to equal lime we equate these expressions (1) as FeO is to CaO as 4:3 we put that ratio into (2). Finally as SiO_2 is to FeO as 3:4 we embody that ratio in (3).

$$40 + 30x + 10y + 10z = 50z \quad (1)$$
$$3(10 + 20x + 30y) = 4 + 50z \quad (2)$$
$$4(40 + 30x + 10y + 10z) = 3(10 + 20x + 30y) \quad (3)$$

These equations are all divisible by 10. It will be convenient to keep (1) for reference in the form:

$$4 + 3x + y = 4z \quad (1)$$

The fallacy is in supposing that we have three independent conditions. But, in fact, one condition is implied by the other two.

To divide by 10 and eliminate x is a very trivial operation. We then arrive at the amazing equation:

$$1 = 0$$

or some other absurdity according to the elimination. In short, having made a false assumption and tried to prove it true, we land nowhere.

Throwing away equation (3) we return to (1) and (2) which with z eliminated gives us:

$$4y - 9x = 17.$$

Here y and x are increasing functions. As $y = 0$ gives *a minus value for* x it is not possible. But $x = 0$ gives $y = 4.25$ as minimum value for y.

This indicates that using 100 lb. of ore No. 1 (as assumed) we may discard ore No. 2 entirely, and take 425 lb. ($100y$) of ore No. 3. The limestone is found by using the reference form of equation (1) above. We get $4z = 8.25$; $z = 2.062$, i.e., limestone ($100z$) 206.2 lb. Our slag figures then as below, ore No. 2 being omitted.

	SiO_2	FeO	CaO	
From ore No. 1	40	10	.....	lb.
From ore No. 2	42.5	127.5	.....	"
Limestone	20.6	.....	103.1	"
	103.1	137.5	103.1	

10 per cent of 425 = 42.5; 30 per cent of 425 = 127.5 (on ore No. 3).

10 per cent of 206 = 20.6; 50 per cent of 206.2 = 103.1 (on limestone).

This proof is perfect, for the three figures 103.1, 127.5, and 103.1 are exactly in the ratio required, i.e., 3:4:3.

How is it that the silica of the limestone adjusts itself to the summation? Answer: It was adjusted in the original statement, and having been involved in equation (1) no subsequent transformation could take it out.

Still retaining our supposition of 100 lb. of ore No. 1 as the basis of our mixture, how can we work in any portion of ore No. 2, if it be desired to make use of that material? Evidently by taking more of No. 3 than the minimum 425 lb. That is, if we assume a value for y greater than the minimum, x becomes a positive quantity. Let us, for example, assume that we shall add 500 lb. of No. 3 ($y = 5$). Substitute in the indeterminate expression, we get $x = 0.3333$ or $100x =$ 33.33 lb. Take equation (1) again, and putting $y = 5$ and $x = 0.3333\ 1/3$ we find $z = 2.5$; that is, limestone = $100z = 250$ lb. Our charge being now as follows, viz.: No. 1 = 100 lb., No. 2 = 33.33 lb., No. 3 = 500 lb., limestone = 250 lb., the proof consists, as before, in taking the percentages as shown by analyses on these weights.

	SiO_2	FeO	CaO	
Ore No. 1 (100 lb)	40	10	...	lb.
Ore No. 2 (33 1/3 lb.)	10	6.7	...	"
Ore No. 3 (500 lb.)	50	150	...	"
Limestone (250 lb.)	25	.....	125	"
	125	166.7	125	"

Again the proof is perfect, for 125:166.7:125 = 3:4:3.

Thus, on the assumption that we use a portion of No. 1 ore, we find that up to a certain point we are restricted to the use of No. 3 only, but having passed that minimum we must use all three. Indeed there is but the one mix that excludes No. 2, viz.: 100 lb. of No. 1 and 425 of No. 3. Try to use less than 425 of No. 3 and we at once get irreconcilable results. This is not worth illustrating.

Finally to complete this discussion of the indeterminate, we may omit No. 1 ore, and recast our mixture, still getting an adjustment that will bring about the required slag. Leaving out No. 1 then, and assuming 100 lb. of No. 2 as our basis, keeping $100y$ for No. 3, and $100z$ for limestone, the problem passes out of the indeterminate class and becomes quite simple, i.e., with but a single solution. We have $SiO_2 = 30 + 10y + 10z$; FeO = $20 + 30y$; CaO = $50z$.

Equations are evidently as below:

$30 + 10y + 10z = 50z$ (SiO_2 and CaO equal)

$4(30 + 10y + 10z) = 3(20 + 30y)$ (Ratio of SiO_2 to FeO)

Divide through by 10, etc.:

$3 + y = 4z$ and $6 - 5y = -4z$ are the reduced forms. These give $y = 2.25$ and $z = 1.3125$. Or (multiplying by 100) charge is: Ore No. 1, 100 lb. Ore No. 2, 225 lb. Limestone, 131.25 lb.

Proof.

	SiO_2	FeO	CaO	
One No. 1, none.				
Ore No. 2, 100 lb	30	20	.....	lb.
Ore No. 3, 225 lb	22.5	67.5	.....	"
Limestone, 131.25 lb	13.125	....	65.625	"
	65.625	87.5	65.625	"

The figures prove absolutely, i.e., as 3:4:3.

Practically, it is absurd to carry a slag calculation into second decimals of a pound. In demonstrating a *method*, however, it is well to carry accuracy far beyond any actual requirement.

Many changes might be rung on themes similar to these. The cases are not of a class likely to occur in every-day practice, but their discussion shows that there may be a variety of mixes all producing the same slag, and that there is no easier way of treating than the representative equation.

The attempt, in fact, to discuss most of such cases by "excess" would be, while hardly an impossible, certainly a tedious and confusing job.

Very notable is the fact that the equation method becomes *relatively easier* as the problem becomes more complex. Also, the fact that by this method the answer

is final at the "first intention," and "readjustment" is never called for, is no small recommendation.

Finally, the proof is readily made, and clinches the figures past all cavil. It is to emphasize the latter point that we have carried out these proofs to an extent that might seem uncalled for.

Denver, Colorado.

Refractometry

BY G. A. SHOOK

II—Instruments

While a first-class spectrometer may be used for the determination of the refractive index of liquids, if it is provided with a hollow prism, considerable care must be taken in making an observation in order to obtain any degree of accuracy. This fact alone renders it unsuitable for commercial work.

The entire range of refractive indices, in the case of liquids is not greater than from $n_D = 1.3$ to $n_D = 1.7$, so that the spectrometer can be used for all sorts of research work. Where time is of any consideration, however, one of the commercial instruments should be used. Indeed practically all research work is now carried out with one or another of the well known refractometers.

In most all classes of work temperature control is an important factor and, therefore, a refractometer should be provided with suitable means for bringing the liquid, under investigation, up to any desired temperature and for maintaining it there for at least several minutes. Most of the instruments now in use are provided with water-jackets of some sort so that a stream of water may be circulated around the liquid. But the appliances that are provided by instrument makers for regulating the flow of water and for maintaining a constant temperature of the water are not always satisfactory. Of course, if the error introduced by a fluctuation of the temperature is not greater than is permissible, for the particular sort of work under consideration, then most any sort of a temperature regulating device may be used.

The choice of an instrument for measuring indices of refraction depends primarily upon two things: firstly the range of the instrument and secondly its sensitiveness.

Among other things which must then be considered are, the amount of the sample required to make an observation, the ease with which a reading may be made, etc.

Some instruments are provided with a direct-reading scale so that no computation nor even a table is necessary for the determination of n_D while others are provided with arbitrary scales making it necessary to use a table if the index of refraction is desired.

Again white light may be used with some instruments, while with others monochromatic light must be used.

For butter and a number of oils the *Zeiss butyro-refractometer* is almost universally used. It has an arbitrary scale divided into 100 equal divisions and it covers a range of refractive indices from 1.4220 to 1.4895. It has an accuracy of about one unit in the fourth decimal place.

A similar instrument is the *Wollney milk-fat refractometer* which is designed for the determination of fat in milk. Its scale is also arbitrary and its range is from 1.3332 to 1.4220.

The *Abbé refractometer* is provided with a direct-reading scale and its range is from 1.3000 to 1.7000. It is used chiefly for edible fats, oils, lubricants, alkalis, linseed oil, petroleum, milk serum, jams, jellies, etc., etc., and it can be used for any substance whose index of refraction falls within its range. It has an accuracy of about two units in the fourth decimal place.

For dilute aqueous solutions the *Zeiss immersion refractometer* is especially suited. Its scale reads from —5 to 105 corresponding to a range of refractive indices of from 1.32539 to 1.36640 and its accuracy is about four units in the fifth decimal place.

For the determination of the dispersion as well as the refraction the *Pulfrich refractometer* is universally used. While it is more particularly a research instrument, it has been used to estimate alcohol and extract in beer and wine. It has an accuracy of about one unit in the fourth decimal place in the measurement of refraction and about two units in the fifth decimal place in the measurement of dispersion. It is made with the following ranges: 1.33 to 1.61 for liquids, 1.47 to 1.74 for solids and 1.64 to 1.88 for substances of exceptionally high refractive power. Its scale is graduated in circular degrees, but by means of a table the refractive index corresponding to any reading in degrees is readily determined.

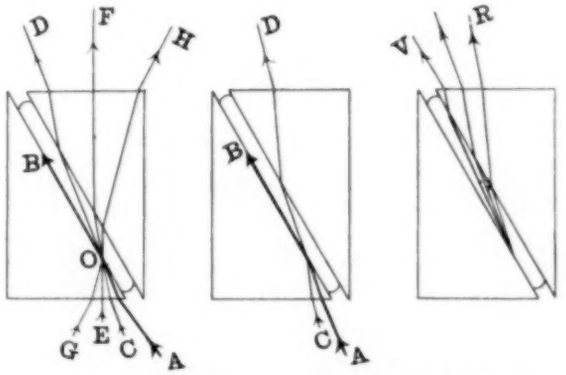


FIG. 1—BUTYRO-REFRACTOMETER DOUBLE PRISM

The Féry instrument has a range of 1.3300 to 1.6700 and is consequently suitable for oils or aqueous solutions. An accuracy of about one unit in the fourth decimal place may be easily obtained. The index of refraction is read directly from a scale attached to the instrument.

The values of the indices of refraction given above are all for sodium light.

The above named refractometers are the ones that are in most common use, although a number of others have been devised.

The theory of some of these instruments will now be taken up in detail.

The Butyro Refractometer

The essential feature of this refractometer and also that of the Abbé is the so-called double prism. This consists of two similar prisms of highly refracting glass, Fig. 1, which are mounted in hollow cases. A stream of water, at any desired temperature, may be circulated around the prisms in order to maintain them at a constant temperature.

The liquid to be examined is placed between the hypotenuse faces of the prisms. The case containing the lower prism is hinged (at the lower edge) to the case containing the upper one so that it may be swung down to allow the introduction of the liquid.

A few drops only are required since the distance between the two adjoining interfaces is only about 0.015 cm.

The inner face of the lower prism is ground, so that every point upon it is a center from which light diverges. Let us now consider the first prism in Fig. 1.

We will suppose that it is filled with a liquid whose index of refraction is somewhat less than that of the prism. Light from beneath the lower face of the lower prism will pass through the point O in the direction OD, OF or OH, and pass out of the upper prism. But for some particular direction as AO, the light will just graze the surface of the liquid and will not be transmitted.

Any ray making a larger incident angle (with the normal to the liquid surface) than AO will evidently be totally reflected and, therefore, not enter the liquid. If, however, a ray such as COD makes an angle, with

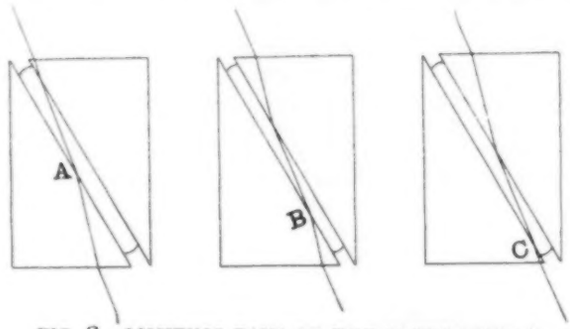


FIG. 2—LIMITING RAYS OF THE DOUBLE PRISM

the normal, slightly smaller than the critical angle of incidence it will *just* be transmitted, so to speak. We will speak of this particular ray, hereafter, as the *limiting ray.*

All of the incident rays to the right of AO will be totally reflected, while all to the left, CO, EO, GO, etc., will be transmitted through the liquid and finally through the upper prism. The same is manifestly true for any point of the ground surface lying on a straight line drawn perpendicular to the plane of the paper through the point O.

Therefore, when one looks at the upper face of the double prism, he sees a light and a dark region separated by a sharp, straight boundary, provided the light is monochromatic.

Now if we consider any other point, along the ground surface of the inner face of the lower prism, such as A, B, or C, Fig. 2, we will have a similar system of rays. That is, parallel to the ray OD, which marks the limit of the light region for the point of divergence O, there will be a ray from the point A, one from B, and one from C, etc.

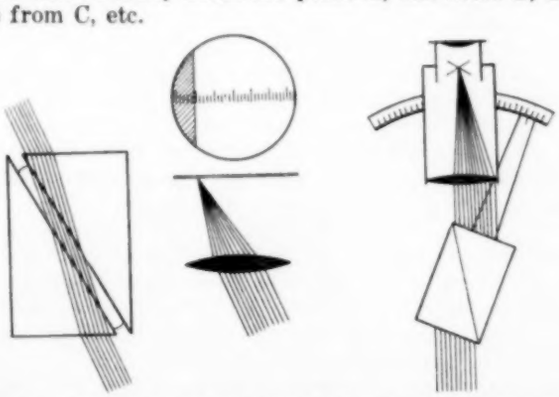


FIG. 3—OPTICAL SYSTEM OF THE BUTYRO REFRACTOMETER

If all of these parallel rays are brought to a focus by means of a lens they will produce an image of the boundary line, Fig. 3.

Moreover, since for every point on the ground surface, the critical angle of incidence must be the same, these limiting rays which just get through the liquid stratum must all be parallel and they must, therefore, all form one image.

The rays which emerge in any other direction, such as OF or OH, will produce by means of the lens images of light centers, as it were, that is to say they will produce a uniformly illuminated area.

In the Butyro-refractometer the upper prism is rigidly fastened to a frame which also supports, directly above the prism, a telescope. The telescope is focused for parallel rays and in the focal plane of its objective is placed a glass disk on which is engraved a scale. On looking through the telescope one sees the field of view divided into a light and a dark region as shown in Fig. 3. The position of the boundary line can be read directly from the superimposed scale.

For a liquid of smaller refractive power than the one just considered, the limiting ray CO will make a smaller incident angle and the emerging ray OD will consequently be more nearly perpendicular, as shown in the second diagram of Fig. 1. The dark portion of the field will in this case extend farther to the right, i.e., the border line will move across the scale.

In the Abbé instrument, instead of a micrometer scale in the telescope, the latter is provided with cross-wires and the double prism is rotated about an horizontal axis until the boundary line coincides with the cross-wires. An index hand or alidade attached to the prism system moves over a scale which is graduated to read the index of refraction, n_D, directly.

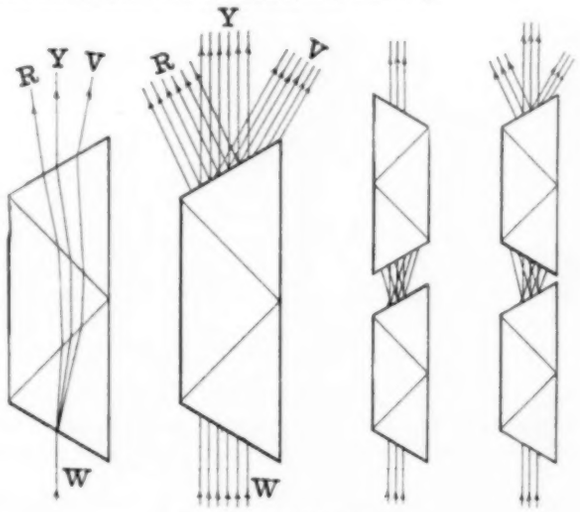


FIG. 4—AMICI PRISMS

Let us now suppose that the limiting ray OD, i.e., the one which produces the image of the boundary line is composed of white light instead of yellow light. As it enters the liquid stratum it will be dispersed into prismatic colors and the rays, corresponding to the various colors, that enter the upper prism, will thus be slightly divergent.

Consequently each ray will give rise to a different image of the boundary line for the position of the image of the boundary line on the engraved scale is determined solely by the direction of the emerging rays. That is, instead of the light and dark region being separated by a sharp colorless line, it will be separated by a colored and somewhat nebulous boundary.

It is readily seen that the upper face of the upper prism might, however, make such an angle with the hypotenuse face that the diverging rays leaving it would all be rendered parallel, in which case there would be but one image of the border line.

For simplicity, let us suppose that we have a violet, a yellow, and a red ray leaving the upper face of the double-prism as illustrated by the third diagram of Fig. 1. Since these three colored rays all make different angles with the prism face each will give rise

to a separate image of the border line, but if they were all parallel they would all be brought to the same focus and consequently produce but one image.

Moreover, the direction of these parallel rays might be made the same as that of the yellow ray, in which case the reading of the instrument would be identical with the reading that would be obtained by using sodium light instead of white light or, in other words, the instrument would be "compensated for sodium light."

Evidently a refractometer can not be compensated for all substances. If it is compensated for a liquid of moderate dispersive power then for a liquid of high dispersive power it will not be quite compensated; that is, the rays leaving the upper face of the double prism will not be parallel and, therefore, a colored border line will result. Again it will more than compensate, so to speak, the dispersion of a liquid of low dispersive power.

The Butyro-refractometer prism is so constructed that the border line is achromatised for butter-fat. For a liquid having a dispersion smaller than butter, the red rays are deviated to the right of the yellow rays as shown in the third diagram of Fig. 1 and the violet rays are deviated to the left of the yellow rays, consequently the border line will be red.

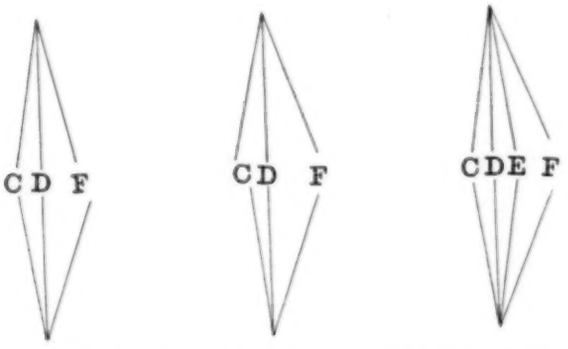


FIG. 5—PARTIAL AND COMPLETE COMPENSATION

For a liquid of greater dispersion the red rays are deviated to the left and the violet to the right of the yellow rays with the result that the border line is blue or violet.

Therefore a blue border indicates a liquid of greater dispersion than that of butter, while a red border indicates a liquid of less dispersion than butter.

It may happen, as was pointed out in the first article on refractometry, that two liquids will show the same refraction for, say, sodium light, but quite different mean dispersions and, therefore, the color of the border line should be noted in making an observation with this instrument. With the Abbé, the Zeiss, or the Pulfrich refractometer it is possible to measure the mean dispersion with accuracy, but such a measurement is not always of value.

The range of such an instrument depends manifestly upon the refracting power of the glass used in the construction of its double prism and it cannot, therefore, be altered in any way except by substituting a new prism having a different refracting power.

The only object of the lower prism is to hold the liquid, to be examined, and in one type of refractometer the lower prism is omitted and the upper prism is immersed into the liquid.

The Abbé Refractometer

The essential difference between the Abbé and the Butyro-refractometer is in the method of compensating for sodium light and in the method of measuring the refraction.

To the double prism of the Abbé instrument is attached an alidade by means of which it may be rotated until the border line coincides with the cross-wires in the telescope, Fig. 3. The alidade moves over a scale on which is engraved the refractive indices.

Since the index of refraction may be read directly from this scale this instrument has some advantage over the one just described. Its chief advantage, however lies in its large range of refractive indices and in its compensating device by means of which the dispersion of practically any liquid may be compensated.

The Abbé compensator consists of two similar amici, or direct-vision, prisms. The amici prism is built of three triangular prisms and the middle prism has a different refractive power from the two outside ones, Fig. 4.

When a ray of white light enters either end of such a prism it is dispersed or spread out as shown. These dispersed rays upon entering the second prism are all bent back toward their original direction, but all to

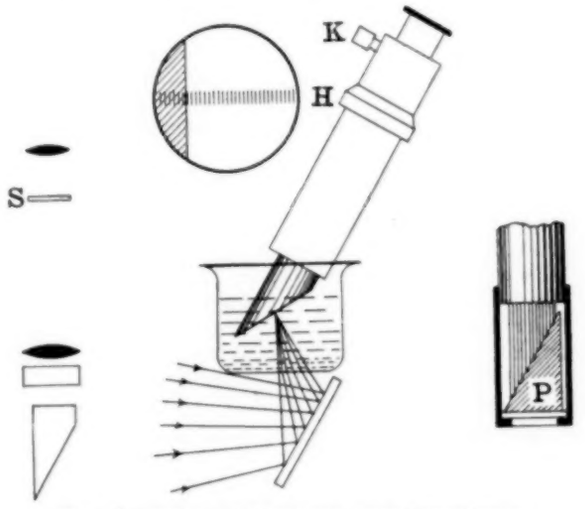


FIG. 6—ZEISS IMMERSION REFRACTOMETER

the same extent, i.e., they are not all parallel and, therefore, the dispersion is not entirely destroyed, although it is diminished. When these rays enter the last prism their dispersion is increased and when they enter the air it is further increased, but the general direction of the emerging rays is the same as the incident ray.

Evidently the prism can be so constructed that a particular emergency ray (say, the yellow one) will be parallel to the incident ray. Therefore, if a parallel beam of white light is incident on one face of such a direct-vision prism the emerging beam which is parallel to the incident beam will be yellow, while the beams emerging in other directions will have other colors as shown by the second diagram of Fig. 4.

It must be remembered that here we are always dealing with parallel rays of light and, therefore, we are concerned with the direction and not at all with the point, on the face of the prism, at which they emerge. At every point there are emerging rays of all colors and their direction is determined by their color. A diagram giving a more complete picture of such a system of rays would be too complicated to be comprehended.

Let us now consider what happens when parallel rays pass through two such prisms, Fig. 4. If the two prisms are oriented so that they oppose each other, as it were, the dispersion produced by the first will be completely annulled by the second so that a parallel beam passes through them without having its direction changed and without being dispersed.

If, however, they reinforce each other the second

prism will augment the dispersion produced by the first. Therefore, by rotating one prism about the common axis of the two it is possible to produce any desired degree of dispersion from zero up to double the dispersion produced by either prism alone.

With respect to the spectrum, the center of rotation, so to speak, is always the D line, but, of course, a prism could be so made that the center of rotation would be any other line.

By means of such an arrangement it is readily seen that the dispersion produced by a liquid, inclosed in the double prism of the refractometer, may be completely annulled. Moreover, the direction of the compensated beam is the same as the direction of the yellow beam so that the reading of the instrument that obtains, when the light is compensated, is identical with the reading that would obtain if yellow light were substituted for white light.

The two amici prisms are mounted in the axis of the telescope between the telescope objective and the double prism and by means of a screw head they may be rotated simultaneously in opposite directions.

The angle through which the prisms must be turned, from the nil position, in order to compensate the dispersion of a given liquid is a measure of its *mean dispersion* and hence by means of the reading of the scale on the drum of the compensator the mean dispersion, $n_F - n_C$, may be computed. Tables are furnished with each instrument to facilitate this computation.

If, therefore, to an observer two oils are given which have the same n_D but different values of $n_F - n_C$ he may distinguish them at once by means of such an instrument.

To be sure, by means of the Butyro-refractometer, one may determine the relative dispersion of oils by the color of the border line, but in such cases the indefiniteness of the border line makes an accurate measurement of the refraction impossible, while with the Abbé the border line may be made sharp and distinct for all dispersions.

It might so happen, of course, that the prisms could be rotated so that the partial dispersion $n_D - n_C$ would be compensated while the remainder of the mean dispersions, namely $n_F - n_D$, would not be compensated as illustrated diagrammatically in Fig. 5.

Again we might be able to compensate the region *F-D*, but not at the same time the region *D-C*, as shown.

In either case a very slight color would be given to the border line, but with most of the liquids with which we have to deal the partial dispersions are proportional to the mean dispersions so that if the mean dispersion of the compensator is made equal to the mean dispersion of the liquid the partial dispersions throughout the spectrum will be practically compensated as illustrated in the third diagram of Fig. 5.

The Zeiss Immersion Refractometer

This instrument is not essentially different from the two just described.

The lower half of the double prism is omitted and the upper half is mounted in the end of a tube which contains a compensator and a telescope, Fig. 6. This tube is either hung on a rack or simply held in the hand. To make an observation it is only necessary to immerse the prism into the liquid whose index of refraction is desired.

The liquids to be examined are placed in small beakers and the latter are arranged in a water bath. This is simply a shallow metal tank provided with a glass bottom and an illuminating mirror so arranged that diffused sunlight may be reflected through the bottom of each beaker. The refractometer may then be dipped into one beaker after another.

In order to keep the beakers at a constant temperature the bath is filled with water at any desired temperature and the beakers are allowed to stand in it about ten minutes before any observations are made or the water is allowed to flow slowly through the tank.

The temperature of the bath is generally indicated by an ordinary thermometer immersed in the water, but in order to be sure that the solutions in the beakers have the same temperature as the surrounding water, it is necessary from time to time to measure the temperature of one or more of the solutions.

Whenever it is possible to provide a large quantity of the material to be tested, this instrument may be used efficiently as a large number of samples can be examined in a comparatively short time.

Its use is, however, limited to aqueous solutions or liquids having an index of refraction of about the magnitude of water.

The method of controlling the temperature of the substances to be tested is not the most satisfactory, however, since it is practically impossible to maintain a constant uniform temperature throughout such a large bath.

When only a small quantity of the sample can be obtained an auxiliary prism *P* is used. It is mounted in a short tube which can be secured to the refractometer tube, thus making a double prism. This arrangement is also used for volatile liquids.

There is a decided advantage, however, in using the single prism, for the border line is sharper than it is when the lower prism is used. Due to the fact that the border line is sharper a higher magnification may be used and consequently greater accuracy is possible.

The border line is made colorless by turning the collar *H* which in turn actuates the compensator. A fine adjustment is attached to the enclosed scale *S* and by means of a drum *K* the tenth part of a scale division may be easily read.

The ease with which this instrument can be manipulated and its extreme sensitiveness renders it invaluable for the investigation of solutions.

The Pulfrich Refractometer

This instrument has no compensating device and, therefore, white light cannot be used.

It is provided with a Geissler hydrogen tube and sodium light is also used, so that the refractive index may be determined for the C, D, F, or G′ line and the dispersion may be determined for the interval D-C, F-D, G′-F, etc.

Light from a sodium flame, or any other source of monochromatic light, is rendered slightly convergent by means of a lens and thence passes into a right-angled prism under grazing incidence, Fig. 7.

The liquid to be tested is held in a short glass cylinder which is cemented to the top face of the prism.

Let us imagine that the three glass tubes in Fig. 7 are all filled with the same liquid and that, moreover, no light can pass into the prism except through the top face.

Since the index of refraction of the glass prism is much greater than that of the liquid to be tested, any ray, *AB*, passing along the interface will be bent into the glass at some point, *B*, and will pass out into the air along the path *BCD*.

For some other point, *F*, a ray entering the cell at grazing incidence will take the path *EFGH* and another ray the path *JKLM*, etc.

Therefore from the vertical face of the prism there will emerge a beam of parallel rays which have their origin from the rays that enter the top face of the prism under grazing incidence.

Any ray such as *PQ*, Fig. 8, which makes a small

angle with the prism surface will, of course, pass into the prism and out again along some such paths as *QRS*. This emerging ray *RS* evidently makes a larger angle with the normal than the ray *CD*, which is due to the light entering the prism under grazing incidence.

Manifestly no light whatever will be transmitted in the direction *UV*, since *UV* makes a smaller angle with the normal than the ray *CD* and would consequently have to arise from a ray having the direction *TQ*, but no light can pass along the path *TQ*, since none enters the prism except through the top face.

Therefore, if an observer were to examine the vertical face of the prism by means of a telescope, focused for parallel rays, he would observe that the field of view were divided into a light and a dark region by a sharp boundary line as shown in Fig. 8.

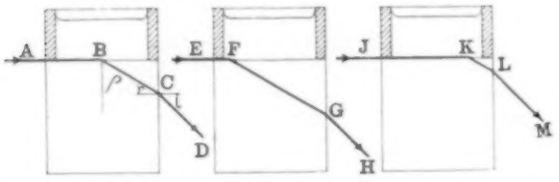


FIG. 7—TOTALLY REFLECTING PRISM OF THE PULFRICH REFRACTOMETER

The angle *i*, Fig. 7, depends clearly upon the refractive index of the glass and of the liquid. For a given glass prism, therefore, *i* will depend solely upon the refractive index of the liquid contained in the glass tube.

Now suppose that the light were passing in the direction *DC*, then if the index (referred to air) for glass is *N* it follows at once that

$$N = \frac{\sin i}{\sin r}$$

Moreover, the index of the liquid (referred to air) is

$$n = \frac{\sin \varphi}{\sin 90} \times N = \sin (90 - r) \times N$$
$$= \cos r \times N = \sqrt{N^2 - N^2 \sin^2 r}$$

But

$$\sin^2 r = \frac{\sin^2 i}{N^2}$$

hence

$$n = \sqrt{N^2 - \sin^2 i}$$

Knowing the index for the glass, *N*, the index of any liquid, *n*, may be readily computed if the angle *i* is known. Tables are furnished with each instrument so that the index of refraction, *n*, may be readily obtained from the value of *i* (in degrees).

In reality the telescope is at right angles to the emerging beam and the beam is reflected into it by means of a 45 deg. prism. The telescope is attached to an arm which rotates about an horizontal axis which lies in the plane of the vertical face of the prism. This arm is provided with an index which moves over a scale so that *i* may be read in degrees. To make an observation it is only necessary to rotate the arm, carrying the telescope, until the cross-wires of the latter coincide with the boundary line between the bright and dark region.

The scale is also provided with a micrometer attachment so that small differences in *i* can be readily measured to within one-tenth of a second. Very often one is concerned only with small differences in the refractive index, such as may be caused by small changes in temperature, in which case the micrometer is extremely convenient.

When it is desired to measure the difference in the refractive powers of two liquids, for example, water and a weak solution of alcohol, a special form of cell is sometimes used. It is provided with a black glass partition and when the cell is in position the partition is perpendicular to both prism faces.

The two liquids to be examined are placed in the two separate compartments. Two border lines will now be observed instead of one and the angular difference between them can be easily and accurately measured by means of the micrometer. All errors due to temperature differences are thus avoided.

The temperature of the liquid is controlled by means of a hollow casing surrounding three sides of the prism, through which a stream of water at any desired temperature or steam may be passed. The liquid may also be heated inside the glass cylinder directly by means of a cylindrical heating vessel, of special construction, which dips into the liquid, *W*, Fig. 8.

The water or steam from the casing of the prism passes through the heating vessel and comes in direct contact with the bottom plate of the same. The vessel can be lowered until it is less than a millimeter from the prism surface so that there is practically no uncertainty whatever as to the temperature of the liquid.

The Féry Refractometer

This instrument has several decided advantages over those just described. The index of refraction of any transparent liquid may be read directly with an accuracy of about one unit in the fourth decimal place and the scale extends with uniform accuracy from 1.3300 to 1.6700. Sodium light is used so that no compensating device is necessary. No auxiliary heating apparatus is required, since the temperature control is an integral part of the apparatus. Moreover, it is only necessary to have 1 cc to 2 cc of the liquid to be tested.

A diagrammatic view of this refractometer is shown in Fig. 9. The essential parts of the apparatus are: a collimator, *C*, of special construction; a telescope, *T* (in line with the collimator); a double cell, *S*, and a heating device not shown.

The outer cell is entirely of metal with the exception of the two larger sides which are plano-convex lenses as shown. The inner widge-shaped cell is made of

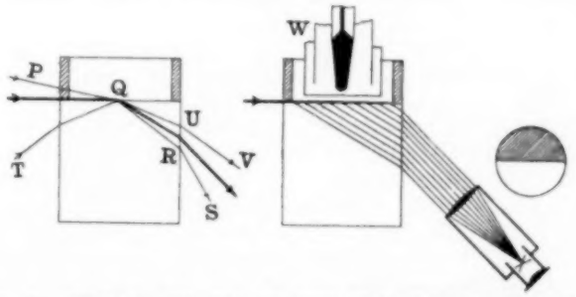


FIG. 8—OPTICAL SYSTEM OF THE PULFRICH REFRACTOMETER

glass and into this cell the liquid to be examined is introduced. The space between the inner and outer cell is filled with water which may be heated to any desired temperature by means of a thermo-syphon which is actuated by a small lamp attached to the double cell. A copper tube of small diameter is brazed to the metal chimney of the lamp and the two ends of this tube are inserted into one end of the outer cell so that an active circulation of the water is produced.

By means of a rack and pinion the double cell may be moved perpendicular to the optical axis of the instrument. When the telescope is properly adjusted, the image of a fine wire in the focus of the collimating lens coincides with the cross-wires of the telescope.

Now when the cell is symmetrical with respect to the

axis of the collimator and telescope, the prism of liquid deflects the beam from the collimator out of its path so that the wire image no longer coincidees with the cross-wires of the telescope.

By moving the double cell, however, the wire image can be made to coincide with the telescope cross-wires and the movement necessary to effect this condition is a measure of the index of the liquid under consideration.

The action of this double cell may be readily understood by means of Fig. 10. If the inner cell were not present then the beam from the collimator would pass directly through the two lenses as shown by the first diagram. If now a wedge of any transparent substance, for instance, glass, were placed in the cell, the beam would be deflected and would not pass directly through the telescope as shown by the second diagram. The

FIG. 9—FÉRY REFRACTOMETER

beam can, however, be brought back to its original direction by moving the cell to one side as shown by the third diagram.

For a prism set at minimum deviation, the index of refraction, in terms of the prism angle, A, and the deviation angle, D, is given by the well-known formula

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\frac{A}{2}}$$

In this case A and B are both small so that the sign is practically equal to the angle when the latter is measured in radians.

Therefore,

$$n = \frac{A+D}{A}$$

or

$$D = A\,(n-1)$$

That is, the index, n, is directly proportional to the deviation D. The lenses of the outer cell constitute prisms of variable angle.

At the pole of the lens this angle is evidently zero, but at the periphery it has a small but finite value. Moreover, this angle varies directly with the distance from the pole of the lens. A little consideration will show that the deviation, D, is directly proportional to the distance that cell must be moved in order to compensate for the deviation produced by the liquid prism.

The divisions of the scale, which is attached to the double cell, are therefore equal; moreover, each division represents the same increment in n. By moving the inner cell (in the direction of its length) with respect to the outer cell the direction of the emergent beam is manifestly altered and consequently the range of the instrument is changed. It is by this simple expedient that the range of the instrument is increased without diminishing its accuracy.

For one position of the inner cell it reads from 1.3300 to 1.5326, and this range is suitable for most of the liquids of industrial interest. By shifting the cell to another position the range of the scale is extended by 0.14 so that it works between 1.4700 and 1.6726.

It is thus seen that the type of instrument which is best suited to a particular laboratory depends entirely upon the class of substances to be analyzed and upon the conditions under which the analysis is to be carried out.

* * *

If the samples to be tested differ widely in their refractive powers then unless more than one instrument can be purchased the choice lies between the Abbé and the Féry refractometers.

If, furthermore, only a drop or two of the sample can be obtained, which is seldom the case, the Abbé instrument would be more applicable than the Féry.

The Féry instrument, however, is more accurate and more self-contained since its heating control forms part of the apparatus. For the exclusive examination of

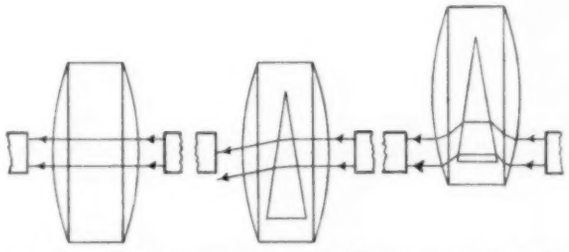


FIG. 10—DOUBLE BELL OF THE FÉRY REFRACTOMETER

solutions the Zeiss instrument is preferable, provided a comparatively large quantity of the sample is available.

If it is desired to measure the dispersion as well as the refraction, then either the Abbé, the Zeiss or the Pulfrich instrument may be used.

The Pulfrich is undoubtedly more accurate for dispersive measurements than the Abbé or Zeiss, but, on the other hand, a measurement of the dispersion is more easily made by means of either of these two instruments.

For research work the Pulfrich refractometer is probably the best all-round instrument.

University of Michigan,
Ann Arbor, Michigan.

Direct shipments of freight into Mexico over the International bridge between Nuevo Laredo, Mexico, and Laredo, Texas, have been resumed.

The domestic iron-ore output in 1913 was the largest in the history of the country, according to figures issued by the Geological Survey, amounting to 61,980,437 long tones, an increase of over six million tons over the production of 1912. Minnesota produced over five-eighths of the total. The Mesabi range produced nearly 70 per cent of the entire Lake Superior output, and nearly 59 per cent of the production of the country.

Stratton's Independence, Ltd., at Cripple Creek, produced 1176 tons of mine ore averaging about $16 per ton, and the mill treated 11,700 tons of low-grade mine and dump ore, during the month of June. The net working profit to the company from both mine and mill operations was $14,420.

The potentials of different minerals when employed as electrodes in different solutions is one of the subjects discussed in *Bulletin* 548 of the U. S. Geological Survey, entitled Electric Activity in Ore Deposits. Although the object of the investigation is primarily related to mining and geology, some of the experimental work is of interest to electrometallurgists. The electric conductivity of minerals, measurements of potential assumed by certain minerals, and electromotive behavior of soluble sulphides are some of the subjects discussed.

Cyanide Practice in the Porcupine District, Ontario, Canada—II

BY H. C. PARMELEE

In a previous article[1] reference was made to the fact that, of the four principal cyanide mills in the Porcupine district, no two have adopted exactly the same method of ore treatment, and that in spite of the general similarity of the ores there is marked diversity in the methods. In order to bring this point clearly to mind, a comparison has been made in Table I, showing the different steps and means of accomplishing them.

TABLE I—COMPARISON OF METHODS OF PROCEDURE ADOPTED AT PORCUPINE CYANIDE MILLS

Mill	Crushing	In	Classifiers	Amalgamation	Concentration	Cyanidation	Filtration	Precipitation	Refining
Hollinger	Stamps and tube mills	Solution	Dorr	None	Deisters	Continuous decantation of slime. Agitation of concentrate	Moore vacuum	Zinc dust	Blast furnace Cupellation
Porcupine-Crown	Stamps and tube mills	Solution	Dorr	Following tube mills	None	All-sliming. Continuous decantation	None	Zinc dust	Rockwell furnace
McIntyre	Rolls, Hardinge ball mills and tube mill	Solution	Dorr	None	None	All-sliming. Continuous decantation	None	Zinc dust	Crucible furnace
Dome	Stamps and tube mills	Water	Colbath	Following tube mills	None	Leaching of sand. Agitation of slime	Merrill press	Zinc dust	Blast furnace Cupellation

Continuous Decantation at the Porcupine Crown Mill

One of the most interesting mills in the district is that of the Porcupine Crown Mines, Ltd., at Timmins. The principal feature of the plant, and the one that lends simplicity to the metallurgical scheme, is continuous counter-current decantation for the displacement and recovery of valuable solution from the impoverished ore-slime. The diagram in Fig. 1 gives an outline of the treatment, and shows also the more important data relative to continuous decantation.

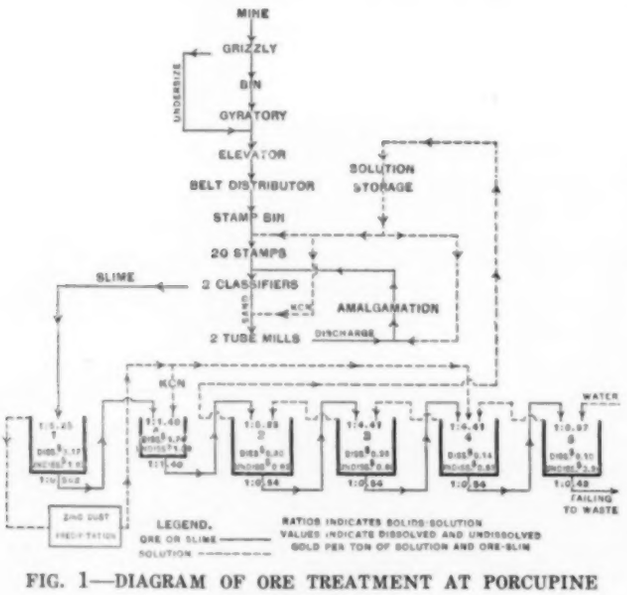


FIG. 1—DIAGRAM OF ORE TREATMENT AT PORCUPINE CROWN MILL

The ore is mainly quartz containing free gold. There is less schist than at some of the other properties, and only 1 per cent of pyrite, as compared with from 5 to 10 per cent elsewhere in the district. The value of the mill feed ranges from $15 to $30 per ton. Some of the gold is coarse and readily amalgamable; the balance is easily soluble in a comparatively weak cyanide solution. The ground ore is granular and settles rapidly, so that on the whole the metallurgical problem is simple and the process well adapted to the requirements and conditions.

There is nothing particularly new in the preparation of the ore for cyaniding. It is screened through a grizzly, 1½-in. spaces, and the oversize is crushed in a gyratory and combined with the grizzly undersize. The whole is then elevated and distributed to the stamp bins. Challenge feeders deliver the ore to twenty 1050-lb. stamps, arranged in batteries of ten each, with separate cam shafts for each group of five. A 40-hp. motor with silent-chain drive serves each battery.

Crushing and Grinding in Solution

The ore is stamped in mill solution returned from the continuous decantation system, four tons of solution being used per ton of ore. The stamp discharge flows to Dorr classifiers which deliver the coarse portion to tube mills for regrinding. The tube mill product is elevated to amalgamating plates and returned to the classifiers. Thus tube milling and amalgamation are performed in a closed circuit, and there is no opportunity for escape of the pulp until coarse gold has been amalgamated or ground fine enough to escape with the slime.

El Oro lining is used in the tube mills, but the Globe liner, previously mentioned in the description of the Hollinger mill,[2] is to be given a trial. The pebble load is maintained at 0.6 the volume of the tubes. The mill solution used in the tube mills is first strengthened with cyanide, and the flow regulated to give 38 per cent moisture in the pulp. The latter is then suitably diluted with mill solution before amalgamation. Preliminary experiments in grinding for cyanidation showed that the critical degree of fineness for this ore was about 150-mesh. In current mill practice 88 to 90 per cent of the ore is finer than 150-mesh and 75 per cent finer than 200-mesh.

The well known difficulty of maintaining amalgamating plates in good condition when using cyanide solution is experienced at this mill, but the plates serve their purpose of catching coarse gold, and effect about one-third of the total recovery. The amalgam is hard and must be scraped from the plates, care being taken not to cut too deep and injure the amalgamating surface.

Continuous Counter-Current Decantation

The overflow of the classifiers, consisting of 1 part of solids and 5.25 parts solution, passes to the continuous decantation plant which comprises five Dorr thickeners, 30 ft. by 12 ft., and two Dorr agitators, 16 ft. by 16 ft., together with the necessary complement of diaphragm pumps for transfer of pulp. This machinery is housed in the long structure shown at the left in Fig. 2, the crushing, grinding and amalgamating equipment being placed in the higher part at

[1] This journal, September, 1914, p. 567.

[2] Ibid.

the right. An interior view of the continuous decantation plant is given in Fig. 3, looking from left to right through the building shown in Fig. 2. The relation of the thickeners and agitators is shown diagrammatically in Fig. 1, and the counter-current flow of solids and solution, and displacement of the latter will be readily understood by reference thereto. There is no filter in this plant.

Examination of the figures given in the flow sheet will show uniform reduction in value of the solution throughout the line of thickeners, ending with a value of only ten cents per ton in No. 5. As the discharge

FIG. 2—PORCUPINE CROWN MILL

from this thickener contains only 0.43 ton of solution per ton of ore, the loss of dissolved gold is but 4.3 cents per ton of ore, which is a remarkably satisfactory result and one that compares favorably with displacement by filtration. Recyaniding tests on the washed tailing show that only an inconsiderable quantity of gold can be extracted without finer grinding. The only water entering the system is used to dilute and wash the pulp in No. 5 thickener and counterbalance the loss of solution in the tailing.

The physical arrangement of the thickeners is such that overflowing solutions pass by gravity from No. 5 to No. 2. A suggestion of the arrangement can be gathered from Fig. 3, wherein the upper part of thickener No. 5 is seen in the central background, and No.

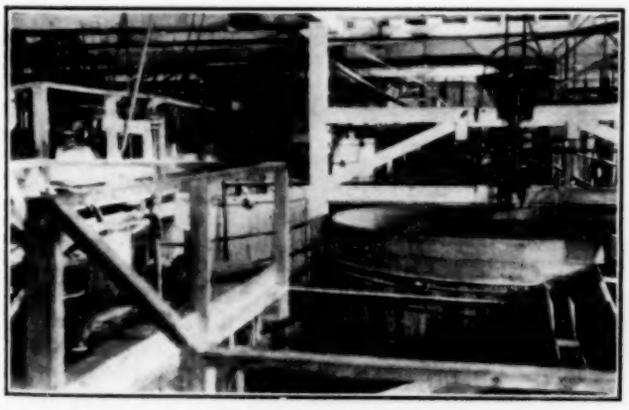


FIG. 3—CONTINUOUS DECANTATION PLANT, PORCUPINE CROWN MILL

4 at a lower level in the left center. No. 3, not visible, is at a still lower level in line with Nos. 5 and 4. The rim of No. 2 is barely seen in the right foreground, with a launder leading to it from the agitator which is in the right center. Thickener No. 1 is behind the agitator. Fig. 4 shows the manner of supporting the thickeners on concrete piers, providing for the proper elevation of the vats and permitting ready access to the discharge pipes.

Thickened Pulp Transferred by Diaphragm Pumps

Diaphragm pumps are used for the transfer of thick pulp throughout the system. These are installed in duplicate at each point of transfer, one being held in reserve. They are ordinary contractor's pumps, costing about $35 each. As originally purchased they are operated by cranks, but give better satisfaction when driven from eccentrics. The change is easily made and results in less lost motion and longer life of diaphragms. As installed at this mill the pumps have two speeds and three lengths of stroke whereby the volume of pulp handled can be varied to suit conditions in the thickeners and possible changes in mill tonnage.

In the design of the continuous decantation plant, four square feet of settling area was provided per ton of dry slime, based on the treatment of 180 tons per day. Only one agitator was originally installed, but

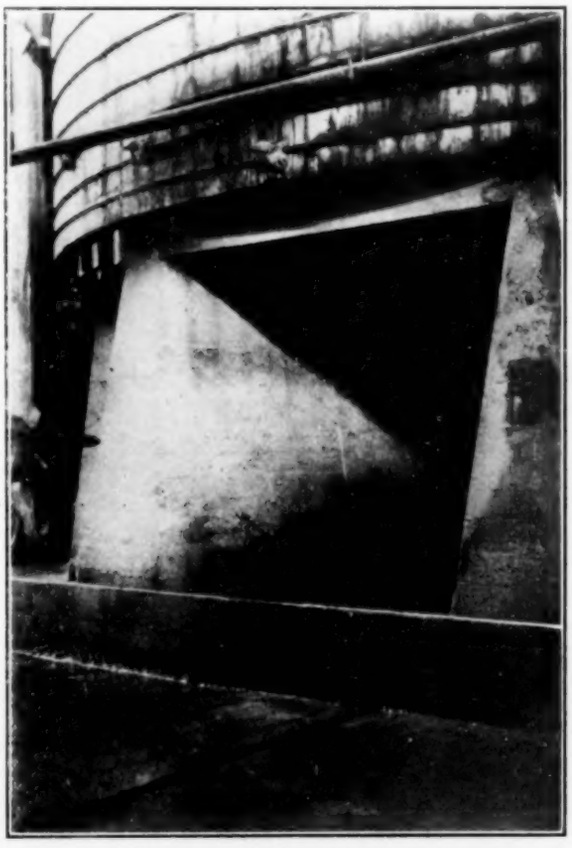


FIG. 4—CONCRETE FOUNDATION FOR THICKENERS

a second has been added, as it was found that dissolution of gold continued through the line of thickeners, indicating insufficient agitation. Although but one agitator is shown in the diagram, there are two connected in series. One-third of the cyanide is added to the barren solution that dilutes the pulp in the agitators, the balance being added at the tube mills. Lime is mixed with barren solution in a small barrel, and the resulting emulsion can be conducted through launders to all thickeners and agitators, so that alkalinity can be maintained as desired.

The ratios and values given in Fig. 1 represent conditions in the month of April, 1914. The strength of solution is 1.25 lb. KCN per ton; protective alkalinity is 1 lb. per ton. Chemical consumption per ton of ore milled is 0.75 lb. KCN and 3.5 lb. CaO. Zinc dust consumption is ⅛ lb. per ton of solution precipitated. About four tons of solution is precipitated per ton of ore treated. Value of the head solution in April was

$2.32; tailing solution, $0.03. Percentage recovery is between 96 and 97, and milling costs range from $1.20 to $1.25, exclusive of charges for administration, depreciation, etc.

Precipitation and Refining

The overflow from thickener No. 1 is the solution precipitated. This solution is first clarified through gravity filter leaves and then pumped to a Merrill press by an Aldrich triplex pump, at the suction of which zinc dust emulsion is introduced. A clean-up is made twice monthly. The precipitate is treated with acid, pumped to a Perrin press and washed therein. The press cake is then partly dried and mixed with fluxes in the following quantities per 100 lb. of precipitate: borax glass, 11.5 lb.; soda, 5.7 lb.; silica, 3 lb. This mixture is then briqueted, dried and melted in an oil-fired Rockwell furnace, yielding bullion about

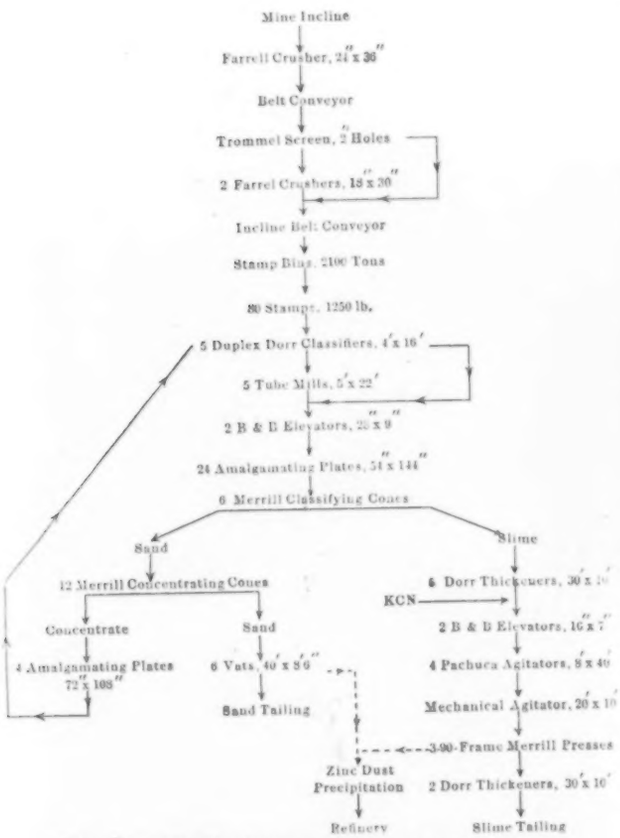

Mine Incline
Farrell Crusher, 24" x 36"
Belt Conveyor
Trommel Screen, 2" Holes
2 Farrel Crushers, 18" x 36"
Incline Belt Conveyor
Stamp Bins, 2100 Tons
80 Stamps, 1250 lb.
5 Duplex Dorr Classifiers, 4' x 16'
5 Tube Mills, 5' x 22'
2 B & B Elevators, 25" x 9"
24 Amalgamating Plates, 54" x 144"
6 Merrill Classifying Cones
Sand
Slime
12 Merrill Concentrating Cones
6 Dorr Thickeners, 30' x 10'
KCN
Concentrate
Sand
2 B & B Elevators, 16" x 7"
4 Amalgamating Plates 72" x 168"
6 Vats, 40' x 8' 6"
4 Pachuca Agitators, 8' x 40'
Sand Tailing
Mechanical Agitator, 20' x 10'
3-90-Frame Merrill Presses
Zinc Dust Precipitation
2 Dorr Thickeners, 30' x 10'
Refinery
Slime Tailing

FIG. 5—ORE-TREATMENT DIAGRAM, DOME MILL

850 total fineness, of which 90 to 100 is silver and the balance gold.

All of the floors in this mill are of cement, draining to a concrete sump at the foot of the mill. A hint of this construction is given in Fig. 4, showing the floor beneath the thickeners. This is a commendable feature in mill construction that contributes to cleanliness and prevents loss of valuable solution through accidental overflows from any of the machines. A centrifugal pump placed in the sump returns the accumulation to the tubemill-classifier circuit.

The Dome Mill

Radical changes have recently been made at the mill of the Dome Mines Co., Ltd., at South Porcupine. Not only has the capacity of the mill been doubled and the mechanical method of preparing and handling the ore been changed, but the metallurgical scheme also has been altered by the abandonment of primary amalgamation following the stamps, and the introduction of sand-slime separation, with leaching of the sand product. The slime is cyanided by agitation and filter-pressing as heretofore. The equipment and new scheme of treatment are shown diagrammatically in Fig. 5. Some data on former mill operation have been published in this journal.[3]

In explanation of the changes that have been made, it may be said that they have been due in large measure to the way in which the mine has developed. When the original mill was designed the mine had not been opened extensively and the ore was high-grade. Furthermore, there was urgent demand for a mill on the part of the company, and the plant had to be designed on rather meager data regarding future ore supply. With the development of the mine, larger bodies of low-grade ore were disclosed,[4] and the problem became one of handling a large tonnage of low-grade ore most economically. Tests made in the interim yielded information that could not have been gained originally, and suggested the changes in practice that have since been made. The remodeled mill will handle double the tonnage of the former, and an effort will be made to treat about 1000 tons of ore daily. There will be

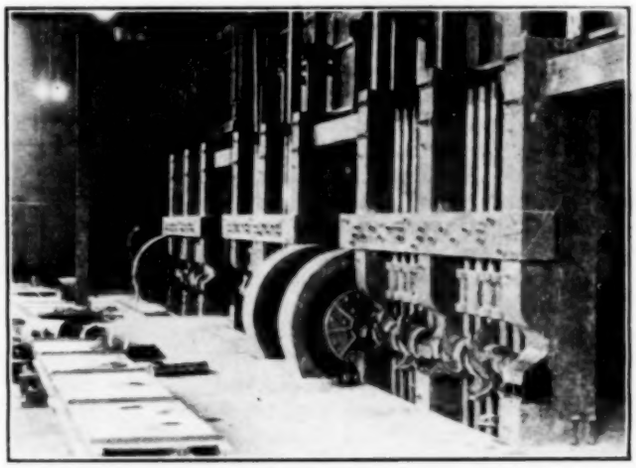


FIG. 6—NEW STAMPS, DOME MILL

little more cost for labor, and grinding cost will be reduced as half the ore will be leached instead of being finely ground and agitated. The general effect of the change, therefore, is to increase tonnage and reduce operating cost.

Jaw-Breakers Supersede Gyratories

For coarse breaking gyratories have been displaced by Farrell jaw crushers with water-cooled bearings. The objection to the gyratories was the high cost of repairs due to excessive wear in the bottom bearings. It appears that fine schist dust gradually worked its way into these bearings and gave considerable trouble.

The crushed ore is elevated by an inclined belt-conveyor to the mill bins, above which provision has been made for screening out the fine portion and by-passing it to the tube mills, thus relieving the stamps of an unnecessary burden.

The new addition of forty stamps has been placed back-to-back with the original forty. A view of part of the new installation is shown in Fig. 6. The battery foundations are of concrete, recessed along the sides to receive 8 in. by 8 in. timbers through which the 1½-in. mortar bolts pass. Both mortar and post

[3]The Dome Mill, D. L. H. Forbes, this journal, May, 1914, p. 349.

[4]In the company's annual report for 1913 it is stated that development work has disclosed a large tonnage of ore assaying from $3.50 to $5 per ton.

bolts are removable without difficulty. The mortars are fitted with manganese-steel liners, and the shoes and dies are of forged chrome steel.

Ore Crushed in Water and Amalgamated

The Dome is the only one of the large Porcupine mills to adopt crushing in water. It is also the only one in which amalgamation is relied upon for the major part of the recovery, amounting in this instance to from 60 to 70 per cent. Of this quantity, about 90 per cent is recovered on the tube mill plates and 10 per cent on the plates following hydraulic classification.

With the adoption of coarse crushing in the batteries, the practice of amalgamating the stamp discharge has been discontinued. Stamp duty has increased from 6½ tons per 24 hours with 18-mesh screen to 14 tons with ton-cap screen of about ½-in. aperture. The battery discharge flows to Dorr classifiers which deliver the coarse portion to tube mills. Formerly, when all-sliming was practiced, the tube mill discharge was returned to the classifier, and only the slimy overflow of the latter was considered a finished product of the grinding department. Now the tube mill discharge is combined with the classifier overflow and much less fine grinding is done than formerly. From 40 to 50 per cent of the pulp is finer than 200-mesh; all will pass 60-mesh.

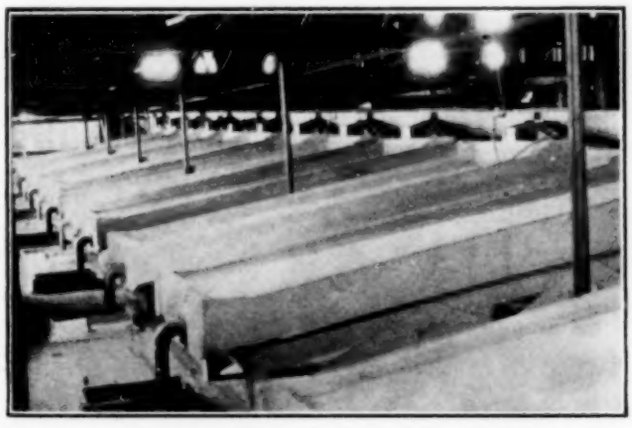


FIG. 7—AMALGAMATING PLATES, DOME MILL

The El Oro lining has been adopted in these tube mills. Silex linings have been tried and found less satisfactory. The former last about nine months as against seven months for the latter. Pebble consumption is 4½ lb. per ton of ore ground.

Twenty-four amalgamating plates, 54 in. by 144 in., are placed on the upper floor of the new addition to the mill, being arranged in two rows of twelve each on either side of a central launder. Fig. 7 gives a view of part of the plates and shows the pulp-distributing system.

Hydraulic Classification of Sand and Slime

From the plates the pulp flows to a series of Merrill hydraulic cones where a separation of sand and slime is made, approximately in equal parts. The sandy portion is then treated in Merrill concentrating cones, where the pyritic concentrate, that constitutes from 5 to 8 per cent of the ore, is separated. This is first amalgamated and then returned to the classifiers and tube mills. By this method of handling the concentrate, it is not separated for special treatment as at the Hollinger, but reground until it is fine enough to escape from the classifiers with the slime.

The sand separated from the concentrating cones flows through Butters and Mein distributers to leaching vats on the floor below the plates. A view of the vat room is given in Fig. 8. These vats are 40 ft. by 8½ ft., with the usual filter-bottom. The surface of the bottom slopes from two opposite sides of the vat to a median line, at each end of which is a gate for discharge of the leached sand. A complete cycle of filling, leaching, washing and discharging requires about 6 days time, of which 5 days is required for leaching. The ore column is 7½ ft. high and the leaching rate is 2½ to 3 inches.

Slime Agitated and Filter-Pressed

Slime from the hydraulic cones is first thickened in Dorr continuous thickeners. Cyanide is added and the pulp is agitated for fourteen hours in four 8-ft. by 40-ft. Pachuca tanks connected in series. Air is used at 20 lb. pressure. The agitated pulp is collected in a storage tank where it is mechanically agitated to prevent settlement, and from which charges are drawn intermittently for filtration through Merrill presses. In view of the well-known adaptability of the Merrill press to the leaching of granular slime *in situ*, it is possible that the Pachuca agitators might be cut out and the slime dewatered and leached in the presses.

Pregnant solution from the presses and the leaching vats is precipitated with zinc dust in the usual manner. Consumption of zinc dust is one-fifth to one-sixth of a pound per ton of solution. The refining process is similar to that used at the Hollinger, except that the precipitate is given an acid treatment before it is fluxed and smelted. The resulting base bullion is cupelled. Amalgam is retorted and refined in the usual manner. The final bullion is about 990 fine, of which 100 is silver.

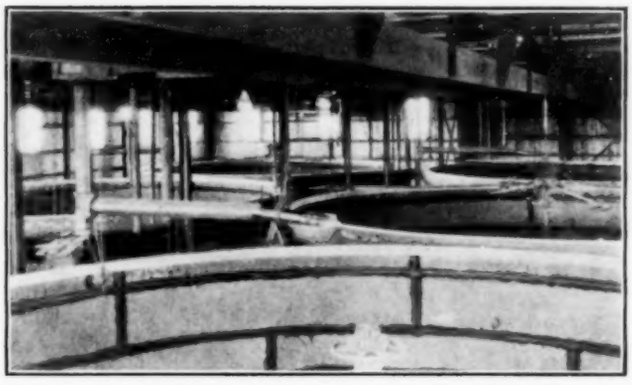


FIG. 8—LEACHING VATS, DOME MILL

The new scheme of treatment has not been in effect long enough to secure average data on operation. In 1913, under the old process of all-sliming, the average value of the ore treated was $8.77 per ton; recovery 94.51 per cent; percentage of total recovery by amalgamation, 60.7, and by cyanidation, 39.3. Average cost of milling was $1.44 per ton, distributed as follows: stamping, tube milling and amalgamation, $0.86; thickening, cyaniding and precipitating, $0.50; refining, $0.08. Coarse breaking and conveying to the mill cost $0.25 per ton, but this item is expected to be materially reduced under the new scheme.

The McIntyre Mill

Important changes and increase of capacity have been contemplated at the 150-ton mill of the McIntyre-Porcupine Mines, Ltd., at Schumacher. Filtration in a Burt revolving filter is to be superseded by continuous decantation. Consequently little will be said about current operations as they are likely to be changed mate-

rially. There are, however, a number of interesting features about this plant that merit consideration.

The ore treated at the McIntyre differs from that at the other mills in the quantity of schist contained. At times this material constitutes as much as three-fourths of the mill feed. Pyrite exists in varying quantities, from 5 per cent to 10 per cent. Some of the pyrite is nearly barren, but much of it carries gold which is readily soluble when finely ground. In fact, when the mill is running on the more heavily mineralized ore, 80 per cent of the total gold extraction takes place in the tube mill-classifier circuit. This action is not so marked when treating ore that is mainly quartz, and subsequent agitation then becomes of greater importance. No trouble is experienced from foul solutions, and aside from being slightly acid, the ore contains no cyanicides.

Rolls and Hardinge Ball-Mills for Grinding

The first distinguishing feature of McIntyre practice is the use of rolls and Hardinge ball-mills for the intermediate crushing performed at the other plants by stamps. A tube mill in closed circuit with a classifier completes the fine-grinding system. This combination of crushing and grinding apparatus offers some advantages in simplicity, both in installation and operation, as compared with stamps. The cost for supplies at the McIntyre amounts to only 7 cents per ton for steel consumed in the Hardinge ball-mills, including balls and the metal discarded in worn liners. Crusher and roll supplies cost 1 cent per ton. In addition to the simplicity of the roll-ball mill combination, there is also a certain advantage in the absence of noise which characterizes a stamp mill. It has been observed before that "noise costs money" in a variety of ways, and that, other things being equal, the quiet machine is preferable to the noisy one.

Coarse breaking at the McIntyre is performed with crushers of the Blake type, set to deliver a 1-in. product. Rolls reduce this to ¼ in., at which size the ore is fed to the Hardinge ball mill and ground in mill solution. Carborundum blocks are successfully used to prevent corrugation of the roll shells, which, after having been in service for fifteen months, had an estimated further life of eight to ten months.

Tube Milling in Closed Circuit

The ball mill feed is equal parts of ore and solution. Balls vary in size from 5 in. to 3 in. in diameter, and both liners and balls are of chrome steel. The following table gives a screen analysis of the average discharge of the ball mill, grinding 150 tons per day and consuming 33 hp.

Mesh	Per cent
+ 20	5.0
+ 40	22.6
+ 60	9.6
+ 100	15.0
+ 200	13.4
— 200	34.4

This product goes to a Colbath screw classifier, where it is diluted with mill solution in the ratio of 3 or 3½ to 1. The slime overflows to Dorr thickeners, the balance going to a tube mill and returning to the classifier. Little dissolution of gold takes place in the Hardinge mill, where approximately 40 per cent of slime is made, and subsequent agitation must be relied upon to extract the gold from this portion of the ore. Approximately 60 per cent, however, gets repeated agitation in the classifier and tube mill, where the major part of the metal is dissolved. Cyanide is added at the tube mill, where the consumption is heaviest. The tube mill pulp contains 35 per cent moisture.

Continuous Decantation of Slime

The overflow from the classifier contains 3 per cent to 4 per cent solids coarser than 100-mesh, and 10 per cent to 12 per cent coarser than 200-mesh. The balance is finer than 200. The plus 100-mesh portion is almost barren and consists of flaky schist that is difficult to grind. Formerly the slime was treated by continuous decantation in two steps with intermediate agitation, and the pulp was finally filtered in a Burt revolving filter. The overflow of the primary thickener

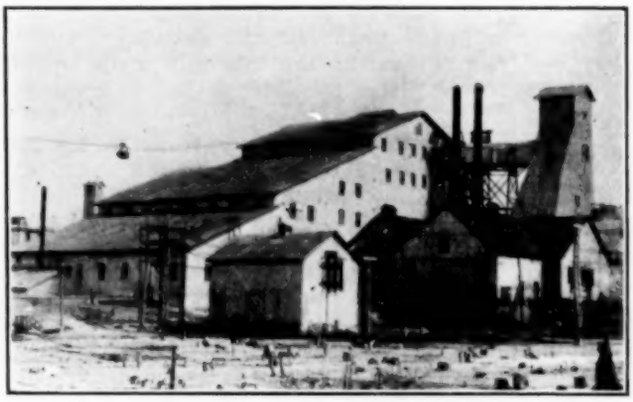


FIG. 9—MCINTYRE PORCUPINE MILL

was precipitated, and the solution from the filter was returned as mill solution.

The proposed change in the system will eliminate the filter altogether and use continuous counter-current decantation as described above in connection with the Porcupine Crown mill.

Despite the presence of much schist in the ore, settlement is reasonably rapid as shown by the fact that 150 tons per day has been handled by a Dorr thickener 30 ft. in diameter and 12 ft. deep.

Zinc dust precipitation has been in use at this mill, precipitating 3½ tons of $2.50 to $3 solution per ton of ore. The precipitate is given an acid treatment, then fluxed with soda, borax, nitre and silica, and melted. The resulting bullion is from 820 to 860 fine. Extraction has been about 95 per cent. Milling cost has averaged from $1.30 to $1.35 per ton, of which $0.50 was for supplies, $0.46 for labor, $0.30 for power, and $0.04 for assaying.

A detailed statement of cost and supplies is given in the following table:

Supplies	Cost per ton
Cyanide	$0.080
Zinc	.075
Lime	.012
Crushers and rolls	.010
Hardinge balls and liners	.071
Tube mill (El Oro liner and pebbles)	.035
Clarifying gold solution	.012
Belting, oil and miscellaneous	.054
Filtering	.033
Pumping and elevating	.027
General repair parts	.028
Refining	.063
	$0.500

The use of continuous decantation without filters was first proved successful in the Porcupine district at the Porcupine Crown mill. Since then it has been adopted by the McIntyre and Vipond, and the Hollinger is to add a 300-ton unit on this basis. The Tough-Oakes in the Kirkland Lake district is also considering the addition of such a plant to its present stamp-amalgamation mill. On the whole the system seems to be meeting the requirements in this district and is likely to be more extensively adopted.

For courtesies extended while in the Porcupine district we wish to express our thanks to local engineers generally, and particularly to Messrs. F. C. Languth and W. F. Battersby, of the Dome; M. W. Summerhayes, of the Porcupine Crown, and R. J. Ennis and A. Dorfman, of the McIntyre.

Chicago Convention of American Institute of Metals

At the opening session of the annual convention of the American Institute of Metals, which was held in Chicago on Sept. 8 jointly with the American Foundrymen's Association, Mr. G. H. Clamer, the president, gave a short sketch of the rise of the society. He said that the Institute was an offshoot of the American Foundrymen's Association. It was organized in Philadelphia in 1907 as the American Brass Founders' Association. Four years later the scope of the society was enlarged to include all non-ferrous foundrymen and the name was changed to American Institute of Metals.

At the succeeding sessions of the convention on September 8-11, the program embracing the reading and discussion of a large number of interesting papers was carried out. There was also a banquet of the allied foundry associations at the Hotel LaSalle on Sept. 10 and an industrial excursion, given under the auspices of the Chicago Association of Commerce, on Sept. 11. The American Foundrymen's Association held a convention at the same time, and the Foundry and Machine Exhibition Company gave its ninth annual exhibit at the International Amphitheater, Chicago, during the convention week.

The New Officers

At the concluding session on Sept. 11 the constitution was revised so that the ten vice-presidents shall be selected from districts representing all of the United States and Canada. Some changes in dues are proposed, but these must be passed upon by the executive committee.

Officers were elected as follows: President, Mr. G. H. Clamer, Ajax Metal Company, Philadelphia; vice-presidents, Messrs. Robert S. B. Wallace, National Cash Register Company, Dayton; W. G. Harris, Canada Metal Company, Toronto; Robert Job, Milton Hersey Company, Montreal; Jesse L. Jones, Oakmont, Pa.; George C. Stone, New Jersey Zinc Company, New York; W. H. Bassett, American Brass Company, Waterbury, Conn.; Fred Moerl, Pullman Company, Chicago; Jacob G. Kasjens, Brass Foundry Company, Peoria, Ill.; H. W. Gillett, United States Bureau of Mines, Washington, D. C.; E. B. Horne, Packard Motor Car Company, Detroit; secretary-treasurer, W. M. Corse, Buffalo, N. Y.

The registered attendance was about 100. The papers relating to metallurgy, metallography and melting practice were discussed on Sept. 10 and 11. In introducing the papers relating to metallurgy of copper, zinc, tin and antimony President Clamer said that there was a great deal of uncertainty among users as to the exact metal content and characteristics of these metals.

Commercial Classification of Refined Copper

The paper by Mr. **Lawrence Addicks**, of Douglas, Arizona, on the above subject points out that the world's copper supply comes from four main sources, sulphide ores, oxidized ores, native ores and scrap.

Perhaps the chief chemical characteristic of copper is its affinity for sulphur and the largest deposits of copper ores consist of more or less complex sulphides.

Metallurgically there are three typical processes for producing crude or unrefined copper from the ore, based on the general principles of oxidising sulphides and reducing oxides—(*a*) roasting, smelting and converting, (*b*) alternate oxidation and reduction and (*c*) direct reduction of oxidized ores.

(*a*) which is a strongly oxidizing process by which the great majority of the American production is made from sulphide ores, results in the almost complete elimination of impurities which have volatile oxides, including some of the worst enemies of refined copper, such as arsenic. Converter bar nearly always runs 99 per cent copper plus silver and is not likely to carry more than a few hundredths of a per cent of any impurity but nickel. (*b*) is the old Welsh process, still used to some extent abroad, based upon the reaction between copper oxides and sulphides to eliminate sulphur as sulphur dioxide gas and carried out in a long series of roasts and fusions in reverberatory furnaces. The removal of impurities is here imperfect although they may be to a certain extent segregated in a portion of the product, whence the origin of the "Best Selected" copper of Great Britain. When the ores are wholly oxidized the copper may be recovered by direct reduction in a blast furnace (*c*) and as this is a strictly reducing process the resulting black copper seldom runs over 96 per cent, due to iron and other impurities reduced.

Except in the case of "Best Selected" and similar English coppers, all of the products from the foregoing processes are given a further treatment or refining, which may be broadly divided into furnace or fire refining and electrolytic refining.

Fire refining is based upon the scorifying effect of cuprous oxide upon base metals contained in a bath of molten copper. The crude copper is melted in a reverberatory furnace and air blown into the bath. Cuprous oxide rapidly forms and dissolves in the bath, the blowing being stopped at or before the saturation point. In this way oxygen is carried to all parts of the molten bath and when there are any metals present which are more easily oxidized than copper, cuprous oxide is reduced back to copper and the oxide of the impurity is formed. If this oxide is not soluble in the molten copper it will float to the surface where it may be removed by skimming. As copper stands high among metals in the order of nobility the metallic impurities with the exception of the precious metals may be readily removed in theory. In practice while elimination proceeds rapidly while considerable quantities of impurities are present, the rate diminishes until traces are reached which cannot be slagged off with any reasonable amount of scorifying. Therefore furnace refining is limited in its application to relatively pure crude copper unless a low-grade refined copper is contemplated. Less than ten dollars worth of silver and gold per ton will justify electrolytic refining.

Returning to the bath of molten copper which has been skimmed clean, it is necessary to reduce the excess cuprous oxide dissolved, and no better way has yet been devised than the old Welsh process of covering the bath with a protecting layer of charcoal or low-sulphur coke and then forcing the butts of green trees or poles of hardwood beneath the surface by means of suitable tackle. The cuprous oxide is reduced in this way until a normal amount corresponding to an oxygen content of from 0.04 to 0.07 per cent is left when the copper develops its best physical characteristics, the condition of the copper being followed by the appearance of the fracture of small buttons cast in a spoon or "say ladle" which is a sort of ductility test and by the swell or depression of the surface of an ingot as it cools, which

indicates the gas content. The copper is then cast by means of one of the several types of ladling machines which have been very successfully developed in recent years.

When the copper is to be electrolytically refined it is first given a rough furnace refining and cast into anode plates, which are then electrolyzed in a strongly acid solution of copper sulphate. The same order of nobility applies, but the great preponderance of copper over the impurities is now an aid as it assists the selective action of the current in depositing only copper at the cathode. Silver and gold are also saved as they are insoluble in the electrolyte chosen and fall to the bottom of the tank as anode mud or slimes to be separately refined and parted.

Copper entering an electrolytic refining entirely loses its identity. Electrolytic cathodes should be very pure. They generally run about 99.95 per cent Cu, much of the missing 0.05 per cent probably being hydrogen. The metallic impurities generally total about 0.02 per cent.

Except for the fact that individual cathodes may vary more or less in impurity content they are ideal material for brass making. Copper producers, however, have never encouraged the sale of cathodes, as there is apt to be some shrinkage in weight during shipment owing to the comparative ease with which nodules or small pieces can be detached either accidentally or intentionally. Also cathode shipments unbalance the work in a refinery in proportion to their magnitude, as melting cathodes into market shapes is a distinct part of the process.

This melting is done in a reverberatory furnace and originally was an exact duplication of the fire refining already described. As the cathode copper is already pure, a simple melting is all that should be required, but molten copper is so susceptible to contamination that until recently the gases from combustion, iron in the rabbles, etc., were absorbed to a sufficient extent to require actual refining. At the present time large quantities of cathodes are being added to the molten charge during ladling and earlier, basic furnaces are being substituted for acid ones, thereby suppressing slag formation, and attention is being paid to keeping coal ashes from blowing over from the firebox, so that a true melting without refining is being approached.

It is well known that cathode copper when drawn into wire will show an electrical conductivity some two per cent higher than the same copper after a subsequent fire refining. This is probably due partly to the fact that chemical impurities in the cathode are chiefly present as a mechanical mixture due to adherence of anode slimes which are dissolved in the copper when melted, making a high resistance matrix around the copper crystals when the metal is cast and cooled; and partly to contamination during melting. It seems probable that the conductivity of perfectly pure soft copper is in the neighborhood of 103 per cent of the Matthiessen standard in common use.

Lake ores are low-grade native copper deposits, which are mechanically concentrated to an 85 per cent mineral. High-conductivity Lake copper (from the surface ores) cannot be distinguished from electrolytic copper, while low-conductivity Lake copper (from increasing mine depths) is really an alloy of copper with arsenic which has certain desirable properties for special uses. Nearly all the elements which markedly depress the conductivity when alloyed with copper are helpful in developing desirable mechanical properties, for example, phosphorus, aluminium, and silica. High arsenical copper running about 0.4 per cent arsenic has now a special market for making firebox plates in Germany, and uses are found for the intermediate grades.

One of the large Lake companies maintains its own electrolytic refinery, and in this way recovers a small amount of silver and eliminates the arsenic, the product still being classed on the market as Lake, although it is equally electrolytic. The old prejudice in favor of Lake on general principles has now largely died out but only with the contemporaneous retirement of the older generation of wire mill managers. Lake copper should be clearly graded by arsenic contents into a series of alloy coppers, the class at one end competing with electrolytic on its own ground, and the other classes sold in competition with arsenical copper from other sources, a field which has only lately been properly appreciated.

The last class of copper produced, which is considered by Mr. Addicks, is that generally known as casting copper, "a very loose term covering a multitude of sins." Specifications for Lake and electrolytic copper may be readily drawn and after a thorough investigation the American Society for Testing Materials has issued a set which should be generally accepted by engineers, as it has already been by the large refineries and wire mills. Casting copper presents a specification problem hopeless of solution at the present time.

In the second part of his paper Mr. Addicks considers the uses of copper. Electrical uses immediately impose a conductivity requirement which rules out everything but electrolytic and high-conductivity Lake, which, as stated, are practically identical coppers. Most of the electrolytic refineries figure on averaging about 100 per cent soft in the electrical conductivity of their outputs. Occasional lots may reach nearly to 101.0 per cent and some may approach 99.0 per cent, while 98.5 per cent is the usual rejection limit, but it is very unusual for a refinery to ship anything for electrical use which is below 99.0 per cent.

No distinction is made between cakes, wirebars and ingots, more than one shape often being cast from a single furnace charge, so that there is nothing to be gained by ordering wirebars, and then cutting them up when ingots are desired. Unless electrical use is specified it is customary to allow an additional leeway of one per cent in conductivity to the refiner, but he rarely needs this and prefers to maintain the higher standard, as copper is often resold several times before it comes into the hands of the actual user.

When copper is not to be put to an electrical use conductivity is of no special value except as a certificate of the absence of more than a trace of a certain class of impurities. The refiner divides impurities into three classes; those that depress conductivity, such as arsenic and antimony; those that impair ductility, such as lead, tellurium and bismuth; and those which are of value if reclaimed, such as silver, gold, platinum and palladium. The elements which depress conductivity are kept within bounds by the conductivity test regularly made. Those which are of value if reclaimed will never reach quantities sufficient to affect the physical properties of the copper as it would pay to re-refine any such copper. The remaining class comprising elements which impair ductility is more difficult to deal with. We know that bismuth, lead, tellurium and probably selenium make copper very brittle even when present in very small quantities. We do not know, however, how to write a specification limiting these impurities as the presence of small amounts of other impurities will neutralize their bad effects. We do know that amounts of lead up to 0.005 per cent have no perceptible effect in mill practice or in alloys. Double this amount shows mild effects. Lead is about the only one of the group ever met with in sufficient quantity to be of interest. As these elements are practically insoluble in copper their effect on the conductivity is proportional to the amount and consequently negligible.

A representative analysis of refined electrolytic copper of 100 per cent conductivity (annealed) is as follows: copper 99.93 per cent, oxygen 0.04, nickel 0.004, iron 0.0035, sulphur 0.003, antimony 0.003, arsenic 0.002, lead 0.002, aluminum 0.001, silver 0.001, selenium 0.0005, tellurium 0.0005, gold 0.00001, phosphorus and bismuth traces.

It will be seen that oxygen is the chief impurity. It has been pretty conclusively shown that too much oxygen makes the copper harder and affects the annealing temperature, the tensile strength of wire, and the number of breaks in a wire machine. This may be due to some surface effects as the "set" surface of a wire bar has a greater oxygen content than the body of the bar and as the oxygen content increases it is possible that this oxidized layer becomes thicker. Another point about high oxygen is that it corresponds to low copper content and to that extent is sold as copper.

In brass making the "set" or "pitch" of the ingot is of no consequence except when the most careful work is done when melting in the foundry to avoid further absorption of oxygen. It is obviously useless to impose rigid conditions upon the refiner if the same conditions are not observed in the remelting and it is only at the largest and best equipped brass foundries that such conditions are even approached. When zinc is introduced into molten copper it acts as a deoxidizing agent, forming zinc oxide. If the copper is kept at very high pitch this source of zinc loss and dirty brass can be greatly diminished and this fact has resulted in a demand for high copper contents in ingots.

It has therefore become a general custom to specify that the copper contents of refined copper shall not be less than 99.88 per cent, which really means 99.90 per cent, allowing 0.02 per cent for assay variations. As this is a rejection point the actual average content is expected to be between 99.92 and 99.94 per cent.

When we come to casting copper a far greater leeway must be allowed as already pointed out. In fact, except in considering the price charged for the material, copper content as but little to do with casting copper. It is best to buy this material on the basis of known brands after finding what brands yield good results in the particular class of work and then insist upon uniform deliveries, judging the material by chemical analysis of the chief impurities.

The physical defects of refined copper are many. Practically all cast copper is porous, doubtless due to the discharge of dissolved gases as the copper cools.

This is analagous to the "piping" of steel ingots but is not so pronounced because copper is cast in a shallow mould instead of on end. These microscopic bubbles are doubtless the cause of roughness in wire. Then there is a class of defects inseparable from ladling, consisting of cold sets and splashes where the copper has run up on the mould and chilled before the main body of metal reaches that point. Then there is porosity or sponginess of the surface due to the mould being either too hot or too cold. Another defect is raised edges on the set surface, generally due to slightly lowered pitch corresponding to excessive oxygen content of the copper. Should the pitch drop still lower "nigger heads" or little black spots will appear. These are the outlets of gas cavities extending some distance into the copper. On the other hand, should the oxygen content be too low the surface of the bar rises and finally breaks open or "spews," an even worse condition.

Many of these defects are always present in more or less degree. Mechanically ladled copper can never be perfect. Specifications require that copper shall be free from mechanical defects, but a reasonable attitude regarding minor troubles on individual pieces is generally necessary to the peace of mind of a buyer. On the other hand, a refinery occasionally becomes careless in such matters and will send out some surprisingly bad work, so that careful systematic inspection combined with an attitude of friendly criticism is the best way for a copper producer and a copper user to live together.

In Mr. Addicks' absence the paper was read by Secretary Corse. In the discussion which followed President Clamer asked why Lake copper sells at a premium over electrolytic if there is no actual difference.

Mr. W. H. Bassett, of the American Brass Company, Waterbury, Conn., in answer, said that the electrolytic people contend that there should be no premium. The Lake people have argued that inasmuch as Lake copper is a natural deposit it has a longer grain than the electrolytic. Mr. Bassett thinks that probably the whole difference lies in the care with which the product is handled in the refining process. Buyers soon ascertain by experience the reliability of the various producers.

President Clamer said he had heard that if James Cooper had lived Lake copper would not be selling at a premium. When it first appeared electrolytic copper was not of the same good quality as has since been attained by its producers. Perhaps the early prejudice against this copper still exists, although at the present time it is probable that it is only a prejudice. Mr. Clamer spoke of a new process of making brass, in which the zinc is added to the copper in the ladles without reheating.

The Production of Zinc

Mr. **George C. Stone,** of the New Jersey Zinc Company, New York, read a paper on "Spelter—Manufacture and Properties." He supplemented it with some reports of tests of various alloys of lead and cadmium with spelter. He also displayed lantern-slide pictures showing how spelter is produced.

The first part of Mr. Stone's paper gives a concise summary of the development of zinc metallurgy and a review of the most representative zinc furnace designs. In the second part the author deals with the impurities in spelter (lead, iron and cadmium) and the effects of these impurities and gives figures on the mechanical strength of spelter. A few notes are added on the limitations of refining processes.

Dr. H. W. Gillett, of Washington, D. C., Mr. Gilbert Rigg, of the New Jersey Zinc Company, and others discussed the properties of various mixtures of cadmium with zinc. The question was discussed whether the occupational disease known as "brass shakes," sometimes experienced by workers in brass foundries, is encountered in zinc smelters. Mr. Stone said he had never heard of a case being caused by pure zinc.

Mr. Bassett said "shakes" do not appear to leave any permanent ill effect, although the attack is disagreeable. Cadmium will give the same symptoms, but more violent.

Dr. Gillett expressed the opinion that copper-vapor poisoning is of a different nature.

Metallurgy of Tin and Antimony

Mr. **William A. Cowan,** of the National Lead Company, New York, read a paper on "The Metallurgy of Tin and Antimony."

The first part of Mr. Cowan's paper dealt with tins and gave a summary of representative methods for the analysis of pig-tin for lead, copper, iron, antimony and copper, arsenic, silver, sulphur, phosphorus, tungsten and stannic oxide. This is the outcome of a co-operative analytic research carried out by Mr. D. M. Buck, of the American Sheet & Tin Plate Company. Mr. A. H. Knight, of Liverpool, Mr. A. M. Smoot, of Ledoux & Co., and Mr. J. G. Smith, of the National Lead Company. The different methods of analysis used by the different investigators were described.

The second part of the paper dealt in a similar manner with the metallurgy of antimony and methods of analysis.

At the conclusion of the paper Mr. Cowan made the interesting statement that at the outbreak of the present European war the price of tin rose from 30 cents to 70 cents a pound, but dropped soon after to 35 cents. The price of antimony rose from 5 cents to 15 cents and then dropped to 10 cents. At present the price of tin in New York is about 10 per cent higher than in London. Mr. Cowan illustrated his address with pictures and gave some analyses of samples from ingots of commercial tin and antimony.

President Clamer remarked that the Addicks, Stone and Cowan papers were prepared by authorities on the subjects presented. They are very valuable, for in the case of some of these metals, it is true that very few users know exactly what they have been getting.

Effects of Repeated Remelting on Copper

In the absence of the author, the paper prepared by **Mr. F. O. Clements,** of the National Cash Register Company, Dayton, Ohio, on "The Effects of Repeated Remelting on Copper" was abstracted by Dr. H. G. Dorsey, of the same company. The interesting experiments described were illustrated by lantern-slide pictures.

The paper gave the results of a series of tests in which the effect of repeated remelting on the soundness of castings was quantitatively measured by an Upton-Lewis fiber stress or endurance machine and chemical tests were made to determine the amount of impurities absorbed during the melting process. The results are given in Table I.

TABLE I
Physical Data

Virgin Metal		First Heat	Second Heat	Third Heat	Fourth Heat	Boron Suboxide	Sample of Boronized Copper Cast Under Ideal Conditions
A. B.	1515	850	845	762	334	2007	3044
R.	100%	97%	96%	96%	96%	103%	117.5
B.	2.7%	5.5%	4.9%	8.5%	22.6%	2.7%	0.74
			Chemical Data				
Copper	99.78%	99.59%	99.49%	99.43%	99.39%	99.56%	
Lead	None	Trace	Trace	Trace	Trace	Trace	
Sulphur	0.03%	0.06%	0.08%	0.11%	0.13%	0.08%	

In Table I "A B" represents the average number of alternate bends, "R" the resistance offered by the test bar to the bend, given in percentage, assuming the virgin metal to be 100 per cent; "B" the percentage of drop-off of resistance in 10-in. lengths. The toughness of the material is in direct proportion to the figure B.

The last two sets of figures included in table I show very conclusively the value of boron suboxide as a flux. Following the directions of the General Electric Company, two ounces of boron suboxide were added to 16 pounds of the badly injured metal. The copper was heated to 1260° Centigrade, in order to secure the best results from this particular flux. The metal was then allowed to cool down to a casting temperature of 1149° Centigrade, and again cast into ingot form. The ingots had a good appearance, were solid, and the fiber seemed remarkably close, as is evidenced by the results obtained on the endurance machine.

Still again, through the courtesy of the General Electric Company, results are given from a small casting of boronized copper produced under ideal conditions. The copper was both melted and cast in a vacuum. No admission of air during the entire process—such a process with electric source of heat and boron suboxide as a flux, permits absolutely no contamination from oxygen and sulphur—high quality fibre should be the result.

There was considerable discussion of this paper by President Clamer, Dr. Gillett, Messrs. C. P. Karr, of Pittsburgh, Frank A. Clark, of Rome, N. Y., R. S. B. Wallace, of Dayton, Secretary Corse, and others.

Dr. Gillett said that it was not shown to a certainty that sulphur was the impurity causing the deterioration on remelting.

Mr. Wallace spoke of some recent tests on aluminium that were remarkable. The second melting produced better results than were obtained with the virgin metal. These experiments are still being continued in the laboratory of the National Cash Register Company. No fluxes are used. President Clamer remarked that the discussion was of considerable importance, as the question of the effect of remelting is always an open one between the foundryman and the metallurgist.

Alloys of Copper, Tin and Zinc

Prof. **S. L. Hoyt,** of the University of Minnesota, read a paper entitled "The Ternary Alloys of Copper, Tin and Zinc—the Kalchoids." This paper, which was illustrated, was of a scientific and technical character. The constitution of the ternary alloys of copper, tin and zinc up to about 50 per cent zinc and 30 per cent tin was studied both by thermal and micrographical analysis. Before a study of the ternary alloys was taken up, an investigation was made of the two binary systems, copper-tin and copper-zinc. The chief results are as follows:

A new heat effect was discovered in the pure copper-tin alloys of the $\alpha + \beta$ range, at 590 deg. C.

In general, the ternary alloys of copper-tin-zinc, up to 50 per cent zinc and 30 per cent tin, were seen from microscopical analyses to behave similarly to the binary alloys of copper-tin and copper-zinc.

The liquidus surfaces, the limit of saturation of the α solid solution, and the eutectoid lines and surfaces were determined.

The eutectoid surface was found to have a maximum near the middle, corresponding to 66 per cent copper, 17 per cent tin, 17 per cent zinc and 590 deg. C. on the eutectoid line. This line shows the β solid solutions to be isomorphous.

The addition of tin to the brasses causes the visible breakdown of the β solution. The amount of the tin necessary varies with the zinc content and with the rate of cooling through the critical range. This gives rise to abnormalities in the microstructure as explained above.

A field of the $\alpha + \beta$ range in the bronzes was found, in which two heat effects in the solid were recorded, corresponding to the pure copper-tin alloys.

In the discussion Dr. Gillett spoke of the importance of the work of Professor Hoyt in relation to the composition of bronzes. Mr. Clamer spoke of mixtures used in the alloys employed for bearings by railroads, and the importance of knowing the effect of zinc in copper-tin mixtures. Mr. Frank mentioned the fact that zinc and phosphorus do not mix well.

Melting Practice and the Use of the Electric Furnace in Brass Foundries

Several papers related to melting practice, particularly the use of the electric furnace in brass foundries. The first paper on this subject was read by **Dr. Herbert G. Dorsey,** of the National Cash Register Company. The speaker described "Tests on Electric Furnaces for Brass Foundries." The furnace under test was a 100-kg one of the Helberger type, made by the Allgemeine Elektricitaets Gesellschaft of Germany. Dr. Dorsey described the construction of the

furnace and the tests made with this furnace under operating conditions. His final conclusions are as follows:

"Considered commercially, from our standpoint this furnace is a failure. It shows many disadvantages and very few advantages. As a laboratory furnace, including experimental work in the foundry on new combinations, it possibly is a good type of furnace, provided a suitable crucible can be obtained, because almost any temperature may be reached and easily maintained for any considerable length of time, and if only a few heats were to be made per week, the occasional renewing of crucible, resistor, plates, etc., would not be bothersome. To prevent contamination of the metal, some other crucible material would be necessary. On fifty-five heats, five different crucibles were used on an average of only eleven heats per crucible. Working at the above basis no more than eleven or twelve heats could be melted per day unless the furnace were operated at night which would mean a new crucible every day. Unless an air blast were used, to cool it, the furnace would scarcely get cool enough during the night to insert the crucible the next morning. Assuming ideal conditions it would require about 31 kw hours per cwt. to melt the metal, while the above tests show about 62 kw hours per cwt.

"Another disadvantage of the furnace is the fact that the crucible is long and narrow and it is difficult to charge the metal in any quantity unless the furnace tender stayed right with it and put it in piece by piece. This would mean that it would require one tender for each furnace which would be rather expensive. In a more convenient form, the crucible would be a short cylinder of large diameter, but electrically this would be bad as it would necessitate greater currents.

"These tests seem to eliminate the Helberger furnace in our own foundry as a competitor with pit fires. We are now working with other types of furnaces, but have not yet had trials enough to reach any conclusions."

Dr. Gillett said that this paper gave the first account of commercial work with the electric furnace in a brass foundry. Because the Helberger furnace did not succeed under the conditions of the work at Dayton, it does not follow that all electric furnaces are inefficient. Dr. Gillett also pointed out that in considering electric-furnace operation the energy needed to heat the furnace before work is begun must be taken into consideration.

Electric Furnace for Medium Temperature

A paper on this subject was contributed by Mr. **Ernst M. Schmelz,** of Detroit. It was read by Secretary Corse and described a furnace which is an evolution of the well-known Stassano type of steel furnace, being built on the same principle, with such particular features added as the lower melting temperature of the charge requires. An experimeneal furnace of this type has been tested at the plant of the Titanium Alloys Manufacturing Company at Niagara Falls, N. Y., Mr. N. Petinot of this company being one of the patenters.

Figs. 1 and 2 show a longitudinal and a cross-sectional view of the furnace. The melting chamber is lined with magnesite, and has an oval section consisting of a semicircular bottom and top, and two straight side walls. There is also an outer lining of fire brick, and the whole furnace is enclosed in a steel shell, and either stationary on its base or supended on two trunions in case it is desirable to use a tilting arrangement instead of the tapping hole.

The heating medium employed is the pure electric arc created between the points of two or more electrodes which enter the furnace from the side. At the points of entering there are water-cooled jackets for the protection of the electrode holders the details of which are shown in Fig. 3. These electrode holders have to be protected from excessive heat and therefore are built hollow and contain an inner tube electrically insulated, from the other parts of the electrode holder, which tube is connected with a water-cooling system. The regulation of the electrode is affected by small hydraulic cylinders placed underneath the water jackets. They are double-acting and governed by four-way cocks mounted on a little standard beside the furnace.

It is evident that if water under pressure is admitted behind the piston of the hydraulic cylinder, this piston and the piston rod will move out and thereby force the electrode holder, with which it is rigidly connected, to move in the same direction, and increase the space between the electrode points. This causes a decrease in the amount of amperage, entering the furnace at a given constant voltage, and correspondingly decreases the heat in the furnace. The reverse movement of the piston will, of course, have the contrary effect, and by this simple and quick-acting system a perfect and smooth regulation of the furnace operations is assured, doing away with all complicated electric starting and regulating apparatus.

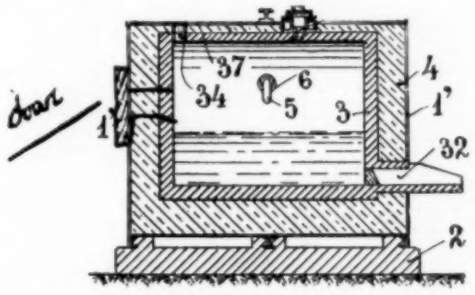


FIG. 1—SECTION OF MEDIUM-TEMPERATURE ELECTRIC FURNACE

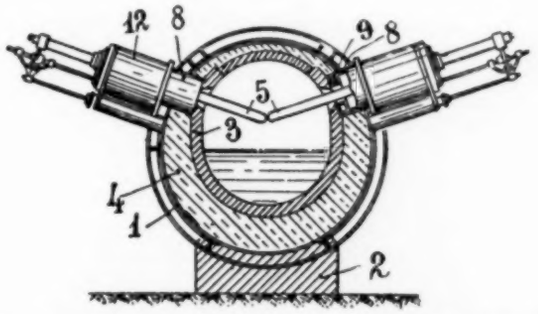


FIG. 2—SECTION OF MEDIUM-TEMPERATURE ELECTRIC FURNACE

To protect the charge from an excessive heat the electric arc is placed approximately in the center of the open space between the surface of the bath and the roof, and on the other hand to prevent a rapid destruction of the roof, and the second or outer lining is much thinner where it covers the roof than on the bottom part of the furnace, owing to the eccentric location of the melting chamber in regard to the outer shell.

The raw material is brought into the furnace through one or more charging doors in the sides which can be tightly closed, which arrangement in combination with the air-tight construction of the electrode holders and stuffing boxes admitting the electrodes affords the special feature of this furnace of a com-

plete neutral atmosphere during the whole time of operation.

In regard to the practical use of this furnace it has several obvious advantages over any ordinary melting furnace using oil or gas as fuel. The use of electricity, the only absolutely pure heating medium, prevents the introduction of any impurities like sulphur, etc., fom the fuel into the charge and the hermetically closed melting chamber affords a complete control over the total process from a metallurgical point of view. Both these features unite in keeping the heat efficiency far above the one obtainable in an open-draft furnace.

An experimental furnace of 120 kw melted 1000 pounds of red copper in less than two hours, using 240 kw-hours per ton of metal, or 0.12 kw-hour per pound. A larger type will, of course, show a tendency to decrase the melting time as well as the amount of electric energy used per ton of molten metal.

The furnace can be designed for the use of D. C. or

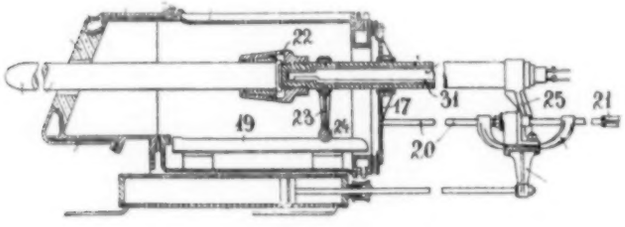


FIG. 3—ELECTRODE HOLDER DESIGN

A. C. current, either single or three-phase and with a voltage of 75 to 220 volts, according to the size of the furnace. The number of cycles is immaterial. The power factor is high, 90 per cent and higher.

The regulation is simple and uses no electrical apparatus, but only a hydraulic arrangement, working on about 30 pounds pressure, which are obtainable most anywhere by simple connection with the city water system. No special transformers or starters are required and the furnace can be operated on any private or public lighting and power plant without fear of disturbing other users.

The upkeep of the furnace is economical, the repairs of the lining can easily be done at night or over Sunday and the electrode consumption is small on account of the closed melting chamber, which prevents any excessive burning out of electrode material under the influence of the oxygen of the air.

Dr. Gillett said in the discussion that it was probable that greater uniformity of metal could be obtained by using the electric furnace than in the case of the fuel-fired furnace. One use of the electric furnace is in the melting of cathode copper as produced by electrolytic copper refining. While open to conviction, the speaker expressed himself as skeptical in relation to arc furnaces for melting copper and zinc. The arc-furnace people should produce their figures.

As to frequency, Mr. Corse said that he understood that 25-cycle energy was all right for melting copper. Mr. Corse added that he understood that Mr. Petinot had had some trouble caused by the rapid destruction of his electrodes.

Dr. Dorsey said that so far as he had learned arc furnaces are not adapted to brass melting.

The Central-Station Point of View

Mr. H. M. St. John, of the Commonwealth Edison Company, Chicago, read a paper on "Electric Brass Melting from the Central-Station Viewpoint." The larger central station companies are rapidly becoming convinced that it is worth while in many instances to give a helping hand in the experimental development of promising processes which use electric power. With respect to the use of electric furnaces for melting brass, as with other processes of a similar nature, it is the mission of the central-station company to act in an advisory capacity to its customers. In order to fill such a role intelligently it is necessary to do a great deal of investigation and experimental work. The needs of the customer must be accurately known and the central-station man must be able to recommend the furnace and method of operation which most satisfactorily meet his peculiar requirements.

The largest single item of cost is the cost of the electric power. Two distinct types of furnace will find use, the "crucible lift-out" type in which the metal is melted in a crucible which is lifted bodily from the furnace and carried to the moulds when the metal is ready to pour, and the tilting type, in which the metal is melted in the furnace chamber and poured into a heated ladle when ready for use. In general the tilting type is the more efficient, but for certain purposes the crucible type is preferred despite its lower efficiency.

The author gives in Table II the results of preliminary tests made on two furnaces, one of the crucible lift-out and one of the tilting type, and gives an estimate as to the approximate power requirements per ton under three systems of operation: (1) Continuous operation for 24 hours a day, (2) ten-hour operation, and (3) "special ten-hour operation" in which case some power is maintained during the night sufficient to keep the furnace hot.

Table II—Approximate Power Per Ton

Metal.	Mode of Operation.	KW Hours Per Ton Lift-out Furn.	Tilting Furn.
Yellow Brass	Continuous	400	280
Yellow Brass	10 hour	580	400
Yellow Brass	Special 10 hr.	540	397
Red Brass	Continuous	500	350
Red Brass	10 hour	720	500
Red Brass	Special 10 hr.	640	467

In further tables costs of power are given for the regular power rates of the Commonwealth Edison Company of Chicago and an approximate comparison of melting costs is made between fuel and electric furnaces. From the figures obtained the following general conclusions are drawn:

"The ordinary oil lift-out furnace will hardly turn out more than eight heats, or about 0.8 of a ton per 10-hour day. If the furnaces are kept hot over night the electric lift-out furnace will increase this by 25 per cent, the tilting furnace by 50 per cent. The net cost of melting is such that the electric lift-out furnace can be used to considerable advantage in melting yellow brass where continuous or 20-hour operation is practicable. When the furnace is kept hot over night the electric furnace, working 10 hours per day, shows a net cost of melting so close to that of oil that increased production and improved working conditions may be considered factors of sufficient importance to swing the balance in its favor. The electric lift-out furnace does not make a good showing in melting red brass; the tilting furnace is much better adapted for this work.

"In melting yellow brass the tilting electric furnace is more economical than oil under any conditions of operation, and its saving is very marked with either red or yellow brass if continuous or 20-hour operation is used. Special 10-hour operation shows a melting cost for red brass a little higher than of oil, but greatly increased production and improvement in working conditions are in its favor.

"To sum up the present situation, the writer believes that we are safe in saying that a reliable electric melting furnace can be used to advantage wherever 20 or 24-hour operation is possible and in many cases where the regular 10-hour day is the rule. It is well to remember also that the electric brass furnace has at this time only started to realize the possibilities of its development and its reliability and efficiency are sure to be largely increased in the near future."

At the conclusion of the paper President Clamer said that proprietors of small brass foundries could not think of installing electrical generating plants to supply energy for electric furnaces. The electric service companies are greatly interested in this subject. It sounded like a foundryman's dream to have the heat come into the establishment over a few wires.

Mr. Frank Schutz, foundry foreman of the H. Mueller Manufacturing Company, Decatur, Ill., gave it as his opinion that it is only a matter of a short time when all brass founders will be using electric furnaces. He said that difficulties were encountered when the oil-fired furnace was first used, but these have been overcome. Similarly, the electric furnace will make its way.

Economy of the Electric Furnace

The government Bureau of Mines is studying the metal losses which are encountered during the melting of brass and other non-ferrous alloys in the effort to find methods of reducing these losses. Dr. **H. W. Gillett** is the alloy chemist of the Bureau of Mines, and he presented a paper on the subject, "Melting Losses in Electric Brass Furnaces," prepared by himself and Mr. **J. M. Lohr.**

The authors first give a review of the melting losses in fuel-fired brass furnaces on the basis of Bulletin 73 of the Bureau of Mines (H. W. Gillett, Brass Furnace Practice in the United States). The metal losses on non-ferrous alloys fall into two classes; first, losses due to metal entrained in the slag and skimmed off before pouring, and to the spilling of metal in pouring or to spilling metal over into the ashes or coal or coke furnaces during melting and to the spilling of metal in pouring. This class of losses are not primarily due to the furnace, but to a greater or less degree of carelessness in the operation of melting and pouring. These losses can be minimized by care.

The second class of losses, however, is due to the conditions in the furnace itself. These losses are due to oxidation of the metal melted while in the furnace, and to the volatilization of zinc from zinc-containing alloys. Metal lost in these ways is not recovered.

Figures of the losses are given as they occur in actual practice under best conditions of operation as well as under average conditions.

There are two main problems requiring solution before electric furnace for brass melting can be put on a commercial basis: First, is the melting loss sufficiently reduced by electric melting to give it a real advantage on that score over the common methods? Second, can the electrical efficiency of any type of furnace which had advantages in regard to metal losses be made high enough so that the cost of power is not prohibitive?

All electric furnaces for brass melting are still distinctly in the experimental and development stage. Hence the development of electric brass melting has not at present progressed far enough to justify a discussion of the various types in regard to the second problem above outlined.

The Bureau of Mines, in its study of electric furnaces for brass melting has, however, made a number of tests on several types of furnaces with particular attention to the question of metal losses. The results are given in the present paper.

From tests with an indirect arc furnace it is concluded that while it is quite possible that an indirect arc furnace may be so designed and run as to give low zinc losses, yet on account of the high temperature of the arc, it will require careful operation to avoid local over-heating and to reduce the losses below those of fuel-fired furnaces. The tests cannot be considered conclusive on this type of furnace, but so far do not look at all promising on the score of metal losses.

On the other hand, tests of an overhead resistor furnace and the crucible lift-out furnace give loss figures on all the alloys tested that show a considerable saving over the losses of even the best run fuel-fired furnaces.

"The figures given on the crucible lift-out furnace can doubtless be duplicated or closely approached on any form of electric furnace that can be tightly closed and in which there is not excessive local overheating. Crucible furnaces with a carborundum resistor and the Hering furnace should give losses of the same order of magnitude as those in the tests cited, although in these furnaces where no carbon monoxide is given off through oxidation of the resistor, it may be necessary to keep the atmosphere of the furnace chamber reducing by some means such as that of dropping in oil, suggested by Fitzgerald, in order to prevent oxidation of the charge. Tilting furnaces will probably give a slightly higher loss, not because of greater loss during melting itself, but because the metal is more exposed to the air and there is more opportunity for volatilization of zinc, during the double pouring from furnace to ladle and from ladle to mold, than in the single pouring from crucible to mold in a crucible lift-out furnace.

"While the problem is not yet settled in regard to arc furnaces, the data set forth in this paper shows that on a number of types of electric furnaces the metal losses, particularly from alloys high in zinc, are very low, as they should be, according to theory. The figures are sufficiently encouraging to make the development of electric furnaces for brass melting worth the time and labor it will take to bring them to the point where the power consumption is low enough to allow them to compete on an over-all cost basis, with fuel-fired furnaces, and thus allow the brass industry to stop the drain on our mineral resources that is now being made by the metal losses in brass melting."

The bulk of the work was done on brass having 16 per cent of zinc, which was poured at about 1,200 deg. Cent. The net result was that it was found that the losses were reduced to one-half or one-third of what they would be in good practice with fuel-fired furnaces. Dr. Gillett remarked that to get good efficiency the electric furnace must be run pretty fast. In his judgment, it is going to pay the brass founder to buy electrical energy, because the resulting saving will show in economy. Co-operation between the founders, the electric furnace builders and the central-station people is needed and is, indeed, in evidence. But it is to be remembered that the electric furnace for the brass foundry has not yet been sufficiently tested, so that the savings mentioned in the paper may be obtained under foundry conditions. There is still much experimental work to be done. Manufacturers are wisely holding back electric furnaces until they are perfected.

The advent of the electric furnace in the brass foundry will be slow but sure. However, it will never

compete with fuel-fired furnaces where metals are now melted down without loss or with losses of less than 1 per cent. But where, as with many of the non-ferrous metals, the losses in melting are a large factor, the electric furnace gives promise of effecting a saving. In fact, the electric furnace in brass melting is no longer a wild hope, but may be regarded as a certainty.

President Clamer said that Dr. Gillett's work was of great value to the industries represented in the American Institute of Metals.

Use of Gas in Brass Melting

Mr. **E. B. Guenther**, of Detroit, gave an abstract of a long paper entitled "The Use of Producer Gas for Melting Yellow Brass." The paper gave the result of tests conducted jointly by the Detroit Copper & Brass Rolling Mills Company and the Westinghouse Machine Company on a producer gas-heated furnace in the casting shop of the former company. Mr. Guenther did not seem to have much use for the electric furnace. He declared that there is at least one plant where producer gas is used for melting brass under commercial conditions, whereas there is not one in which the electric furnace is used. A gentleman connected with the Langsenkamp plant, where producer gas is used both for engine drive and for fuel in furnaces, said that the coal used is Pocahontas mine run and that the consumption is 8 tons a day.

Mr. **Fred L. Wolf**, of the Ohio Brass Company, Mansfield, Ohio, gave the substance of a paper prepared by himself and Mr. **Robert B. Burr**, entitled "Tests of Natural Gas-Fired Brass-Melting Furnaces Under Factory Operating Conditions." The object of these tests was to endeavor to increase the efficiency of the furnace by making use of the present equipment without entering into too great an expense for alterations. The gas was obtained from the medium pressure mains. The air necessary for combustion was obtained from an independent blower outfit which was installed so that any air pressure up to 32 ounces could be obtained at will, as the highest available pressure, under factory conditions when all equipment was in use, was approximately 14 ounces. The results of our tests showed that by a proper burner construction and manipulation, as efficient results could be obtained with 4 ounces of gas and 14 ounces of air, as with higher pressures, and with, of course, a consequent reduction in the cost of compressing the air.

The experience of the authors shows that where the shell or drum of the ordinary pit type of coke furnace is sufficiently large to allow a reasonable thickness of lining this furnace equipped with a simple tube burner and pre-heating coils, which allows the use of low pressure gas and air, is as efficient as any of the more complicated furnaces tested. Its maintenance cost is practically nil, which applies to the burner also, and our experience shows that it may be continuously operated without delay for repairs and with no inconvenience to operators.

Pyrometers

Dr. **H. W. Gillett** summarized an exhaustive paper he had written on the subject of "Pyrometers for Molten Brass and Bronze," in which radiation pyrometers, optical pyrometers and thermo-electric pyrometers are classified. He described an improved thermo-electric instrument in which a composite protective tube is used, the body being silfrax, but provided with a tip of molybdenum, which is not attacked by hot molten brass or bronze. However, according to the speaker, there is not yet any pyrometer which can be considered an all-around practical foundry tool.

Electric Brass Melting with the Hering Furnace

Mr. **G. H. Clamer**, of Philadelphia, gave, in brief abstract, a paper written by himself and Dr. **Carl Hering** on "Electric Brass Melting."

In the paper the general advantages of electric furnaces for brass melting are first discussed, and it is pointed out that the ideal method would be to melt and pour as quickly as possible, hence in as small lots as the particular conditions of the foundry require, though this, of course, need not be carried to extremes. It is thought, however, that for small castings at least a high power tilting brass furnace of this type could be constructed small enough to be transported to the molds, pouring directly into them.

A description of the general construction of the Hering pinch-effect furnace is then given, and it is pointed out what a large amount of heat is carried out

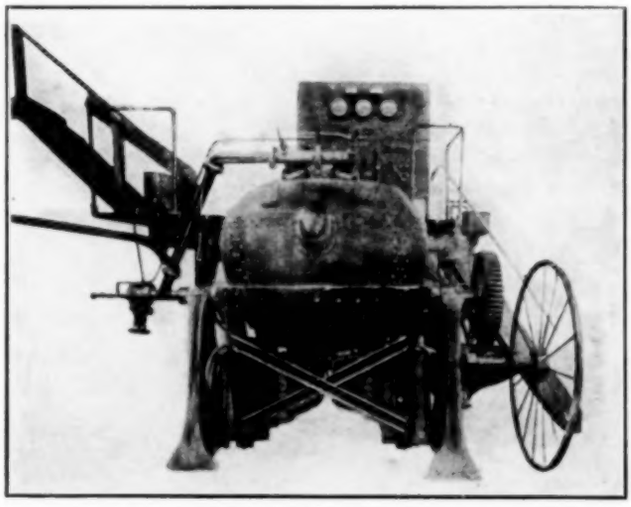


FIG. 4—TWO-PHASE PINCH EFFECT FURNACE

of the heating holes in the furnace bottom ("the resistors") effectively by the rapidly flowing metal; it exceeds that of a row of electric arcs in those holes. At present about 25 to 50 kw. are converted into heat in each hole (or roughly about 90,000 to 200,000 B. T. U. or 20,000 to 45,000 kg. cal. per hour), with the probabilities that this can be considerably increased. The correct proportioning of these holes and the current are of great importance. These proportions are quite different for brass than for steel. The furnace must be especially designed for each metal, though variations in the compositions of brasses and bronzes can be taken care of in the same furnace by regulation of the electric current.

Even copper with its very low resistance can be melted commercially in these furnaces without requiring impractical proportions. The higher the electrical resistivity of a metal the better the proportions become.

The power factor of the furnace, even with 60 cycles, is not low, being "in the eighties and nineties, and even this small reduction from 100 per cent was no doubt largely, if not all, in the transformers and could be avoided in a better design of the transformers. In a steel furnace with a frequency of 25 the power factor was practically 100 per cent, hence perfect."

The Hering furnace has so far been used for melting very light brass and bronze chips, which gave trouble in the fuel furnaces. In melting many tons of these light, curly and oily brass chips with much mechanically mixed iron, they cast in the form of clean ingots nearly 8 pounds per kw. hour, delivered

to the furnace transformers, equal to about 12.5 kw. hours per 100 pounds poured. But there were various losses which can be avoided in future. Short runs, with clean ingot charges, indicated that, even with the easily avoidable excesses in the losses, 10 pounds per kw. hour could be obtained in this furnace, hence, in better designs, even still better efficiencies than this can reasonably be expected. But this figure depends largely on the amount of superheat required by the particular foundryman.

The economy of the electric melting could be greatly increased by preheating the charge with a fuel flame,

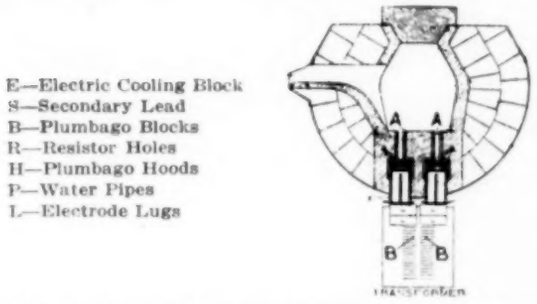


FIG. 5—JACKET AND ELECTRIC CONNECT FOR 120-KW TWO-PHASE PINCH EFFECT BRASS FURNACE

preferably in an auxiliary furnace, to only such a temperature at which no oxidation takes place.

Comparisons are then made between the operation costs of fuel-fired and electric furnaces for brass melting. Finding as an average 38 cents per 100 pounds for coke furnaces and 20 for the electric, the saving in a plant melting 20 tons per day, would be nearly $22,000 per year of 300 days; or for oil furnaces at 43.2 and electric at 20 cents, the saving would be nearly $28,000 per year, which should be credited to the first cost of the electric furnace.

The development of the Hering type of furnace involved many difficulties largely because it was an entirely new and somewhat radical departure from existing practice, hence no precedents existed. The troubles encountered in its development were chiefly in finding the proper proportions of the electric parts for which no precedents existed and which could be determined only by trial, involving the erection and destruction of many experimental furnaces. The electric resistivities of the molten metals had to be determined as they were not then known to the art. The electrodes, which are of metal, are necessarily liquid at their hot ends and solid at the cold ends, hence must be carefully designed and proportioned, so that on the one hand they do not melt back too far, and on the other hand do not carry off too much of the heat. The undesirable circulation or washing of the metal at the hot ends of the electrodes where they join the heating holes has been avoided by a special construction of the electrodes.

The outside of the 110 kw. furnace is shown in Fig. 4. It is a two-phase furnace. The two transformers are seen underneath; they tilt with the furnace. For each transformer there are two vertical heating holes, thus making each transformer independent of the other. A three-phase furnace with three transformers, three electrodes and three heating holes would be better.

Fig. 5 is an outline and diagrammatic vertical cross section in which R are the heating holes or resistors.

In a later and better design the hearth, electrodes and heating holes are arranged as in Fig. 6, which makes the relining and repairs of the heating holes easier than when they are at the bottom, as they are in Figs. 4 and 5. This improved form also permits turning around the spout as a center, which is considered by many to be an important advantage, and which does not exist in the form in Fig. 4.

The furnace shown in Fig. 4 has been criticised for being so large outside. These large outside dimen-

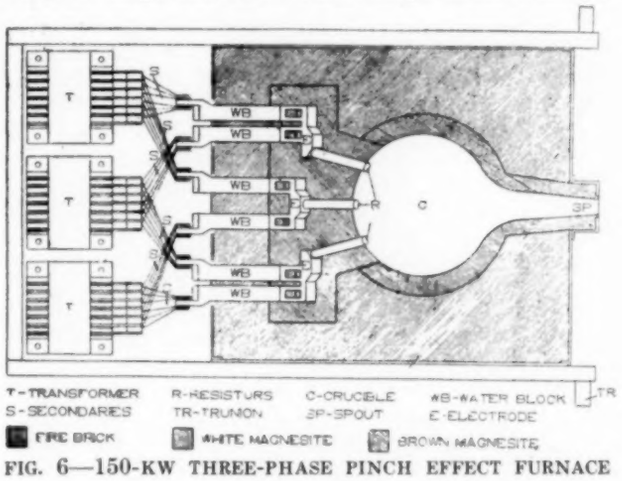


FIG. 6—150-KW THREE-PHASE PINCH EFFECT FURNACE

sions are not essential and the furnace could have been made far smaller for the same capacity of metal if desired or by using an outside lining of kieselguhr brick. But thick walls economize heat, which is more important in electric than in fuel furnaces, as the cost per unit of heat is, of course, greater. Our argument was that bricks are cheaper than kilowatts, hence that the first investment in thicker walls was more economical than to suffer the continued losses of expensive kilowatts.

The Hering furnace will soon be in regular, 24 hours per day, operation at the foundry of the Ajax Metal Company in Philadelphia, they having made very satisfactory terms with the local power supply company.

Reports of a number of other papers had to be reserved for our next issue.

A New Aluminium Alloy

A London company has placed on the market a new alloy named "Ormiston Metal," after its inventor, Mr. H. O. Ormiston, of Sydney, Australia. The metal, which is white and bright, contains about 97.5 per cent of aluminium, and can be produced either directly from bauxite clay with the addition of the requisite chemical compounds, or by alloying pure aluminium. It is stated that this metal will take a polish equal to that of silver or nickel, which it retains permanently, and that it is not corroded by the atmosphere, by sea air or by food acids. For equal weights its electrical conductivity is greater than that of copper or any known alloy. Tensile tests taken at the National Physical Laboratory show a strength of 16 tons per square inch, and tests in Australia went up to 20 tons. Perhaps the most important claim is that it can be soldered either to itself or to other metals with an ordinary soldering iron or blow-lamp and can be brazed or welded without difficulty.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in June, 1914, was 60. The total quantity of ore milled during that period was 2,233,507 tons. There were 9,803 stamps in operation with an average duty of 8.82 tons per 24 hours. Tube mills in commission numbered 294. The yield for the month was 717,926 fine ounces gold.

Notes on Chemistry and Metallurgy in Great Britain

(From Our Special Correspondent)

The War and the Engineering Industries

Considerable dislocation of most of the British industries inevitably occurred during the first two weeks of the war, but there are manifest signs that the difficulties are being grappled with firmly and will soon be overcome. In the steel trade, particularly in Scotland, the cessation of the supply of continental material has been rather severely felt by engineers and shipbuilders, while the supplies of ore for the furnaces are by no means equal to the demand. In the Tyne district there has naturally been a large increase of work in the shipyards, and the Elswick works are as busy as they can be. At Sheffield some of the works not engaged in the production of war material have been put on short time, but the increased activity of those that are so engaged compensates for the temporary adverse condition of the others. In South Wales there is every prospect that the iron and steel industries may anticipate a period of renewed prosperity, and probably a considerably higher output than has ever been previously attained. Birmingham, of course, produces a great output of war material, and large orders from government have been placed with the Birmingham Small Arms Company and other concerns.

Mechanical engineers in general are not so lucky, and the wholesale cancelling of orders has been acutely felt. In the Swansea district the tin-plate workers may safely look forward to a vastly improved condition of affairs. More than 100 tin-plate mills in this neighborhood will shortly be re-started, and it is estimated they will employ upward of 5000 hands. The engineers of Liverpool are more fortunate than some of the others. A large influx of government orders has been keeping practically all the works very busy, while there is every sign that this brisk state of affairs is likely to continue for a considerable time.

As a result of the ability of the British navy to keep practically the whole of the trade routes at sea free from interference, the alarm which was so general during the first week or two of the war has almost totally subsided, and it is not too much to hope that the British engineering industries will very soon resume a condition, not perhaps quite normal, but at all events approaching it.

The Féry Gas Calorimeter

The determination of the calorific value of gas involves, at present, the use of expensive and intricate apparatus under expert supervision, as well as the expenditure of considerable time. M. Féry, the inventor of the well-known pyrometer bearing his name, has now produced a simple instrument which gives a quick and, apparently, a reliable reading. When a flame is inclosed in a chimney the current of the gaseous products of combustion admixed with surplus air has a velocity proportional to the calorific value of the material undergoing combustion. The new instrument consists of a burner and chimney with a cylinder below through which all the air passes; while at the lower end of the cylinder an anemometer is suspended, by its gravitic center, and by angular displacement, indicates the velocity—and, consequently, also the calorific value—on a calibrated scale. The accuracy of the determinations depends on the gas being supplied at a strictly uniform rate, and to ensure this a sensitive governor regulates the flow.

The Supply of Tungsten

Several months ago it was pointed out in these notes that Great Britain was dependent on Germany for practically the whole of the supply of tungsten. But the question of the production of tungsten in England has already been under serious consideration by influential firms connected with the steel trade, and the Luton firm which has for some time past devoted its attention to the production of ferrotungsten and similar alloys will soon be in a position to assist in meeting the requirements of manufacturers of tool steel and other special steels.

The Iron and Steel Institute

The meeting of the Iron and Steel Institute which was to have been held in Paris in September will, necessarily, now not take place. There were hopes that the assembly would be transferred to London; but it has been decided to abandon the meeting altogether. The papers will be sent to the members by post, and criticisms in writing will take the place of the usual discussions, and will be duly published.

The Institution of Mining Engineers

The annual meeting will be held on Sept. 9 at Stoke-on-Trent. The following papers are included in those put down for reading: "Absorption of Oxygen by Coal," by Messrs. T. F. Winmill and J. I. Graham; "Self-Contained Rescue Apparatus and Smoke Helmets for Use in Irrespirable Atmospheres," by Dr. J. S. Haldane, and "Unknown Clays in Coal Mines," by Dr. J. W. Mellor. Sir William Garforth will preside.

The Distribution of Phosphorus in Steel

Among the papers presented in the Engineering Section of the recent Australian meeting of the British Association was one by Dr. W. Rosenhain describing a method of treating steel specimens, elaborated by himself and Mr. J. L. Haughton, which, they claim, brings out structural features much more satisfactorily than do the ordinary etching processes.

The author remarked that, while the deteriorating effect of phosphorus on the mechanical properties of steel is unquestionable, it is hardly credible that less than 0.04 per cent of phosphorus could exert a serious effect if it were uniformly distributed throughout the metal. The reagent employed in their research was a solution of ferric chloride acidified with hydrochloric acid and with the further addition of small proportions of chlorides of copper and tin; and its action was to replace the small amount of iron dissolved from the specimen by an equivalent quantity of copper.

With a steel of ideal purity the film of copper would be quite uniformly deposited on the ferrite, but in the case of steel containing phosphorus compounds the purest portions of the surface are coated first and those parts richest in phosphorus are left bare for a considerable time. When carried to a certain point the appearance of the surface developed by the etching corresponds almost exactly, under the microscope, to that produced by heat-tinting, but with less prolonged action features are brought out which are not revealed by the etching reagents usually employed or by heat-tinting.

From a close examination of these features the author has been led to attribute the origin of the banded structure of phosphoric steel to processes occurring during the first solidification of a solid solution alloy; and he concludes that the coarseness or fineness of the banding in the finished steel is determined by the scale of crystallization which occurred in the original ingot, although the crystalline structure may have subsequently undergone repeated modification by thermal or mechanical treatment.

Manganese Steel

Among the several Iron and Steel Institute papers which have not yet been reported, one on manganese steel should first be mentioned.

A paper by Sir R. A. Hadfield and Professor Bertram Hopkinson described the magnetic and mechanical properties of the manganese steel containing 12 pe rcent of manganese and 1.25 per cent carbon. When heated to 1000 deg. C. and quenched in water the steel is very tough and almost non-magnetic, but when reheated in the neighborhood of 520 deg. C. for about 600 hours, it will acquire a degree of magnetism about 60 per cent of that exhibited by pure iron. It also requires magnetic properties at lower temperatures, but the change is very much slower.

It was found that the magnetism acquired at 520 deg. C. was not got rid of nor diminished by reheating at 550 deg. C., but that at higher temperatures than 640 deg. there was a rapid diminution and the magnetism was almost completely eliminated after heating for a few minutes at 750 deg. C. Heating curves demonstrated that this sudden change of properties at about 700 deg. was accompanied by a perceptible absorption of heat.

This manganese steel, after cooling in the ordinary way in air, subsequent to casting or forging, is somewhat brittle, hard, and non-magnetic: after quenching in water from 1000 deg. C. it is very ductile but remains non-magnetic, and any treatment of the water-quenched-steel which renders it magnetic to only a slight extent also tends to make it hard and brittle, and when it has acquired one per cent. of the magnetism of pure iron it has lost its toughness to such an extent as to be useless for ordinary purposes.

The hardness generally increases with the magnetism, but the increase in hardness is not comparable with the hardness acquired as a consequence of the accession of the initial traces of magnetism.

Well defined changes in the micro-structure occur during the transition from the ductile to the hard and brittle condition.

Cause of the Hardening of Metals

In a paper by Professors C. A. Edwards and H. C. H. Carpenter the authors contend that the process of annealing or softening metals by heating to fairly high temperatures and subsequent slow cooling results in the extensive growth of crystals. When alloys, such as carbon steels are quenched, severe stresses are induced which cause marked twinning of the crystals. The greater hardness brought about by quenching steels from a temperature above their highest critical point is directly as the velocity and thermal extent of the suppressed inversion; and the relation between crystal twinning and percentage of carbon is plainly evident.

Dr. Beilby showed that when metals are depressed and hardened by cold working amorphous layers are found on the surface, and similar amorphous layers are found on all surfaces on which twinning takes place. The authors are of opinion that the presence of these amorphous layers is the ultimate cause of hardening by quenching steels. From these effects it appears that the cause of hardening by quenching is precisely similar to that of hardening by cold working, namely, the internal deformation of crystals.

Direct Production of Steel from Ore

A paper by Messrs. Ernest Humbert and Axel Hethey dealt with the direct production of steel from ore in the electric furnace. The difficulties experienced in the ordinary manufacture of steel in getting rid of oxygen, phosphorous, sulphur, and silicon and the practical impossibility of eliminating hydrogen and nitrogen induced them to experiment on a method of producing steel of a higher degree of purity. They arrived at the conclusion that under satisfactory conditions the electric furnace is suitable for the practical production of high-grade steel direct from the ore; and they claim that the predominent feature of the steel manufactured in their experiments is its great toughness. Forge tests carried out at the furnace showed that even when containing a high percentage of carbon the steel would easily bend without fracture.

Utilization of the Heat of Molten Slag

The Slag Power Company seems, to a very great extent, to have solved the question of using up the heat in furnace slag. Experiments have been carried on for about four years at Messrs. Bell Brothers' works at Port Clarence, and at last all the difficulties which were encountered in the early stages appear to have been effectually overcome.

The original idea was to use the steam directly produced by the immersion of the slag in water, but the presence of sulphuretted hydrogen, sulphur and other impurities rendered the use of such steam inadmissible in a turbine, and no efficient process could be devised for the removal of those impurities. The method now adopted is to use this impure steam generated by the immersion of the slag in the water to supply heat to a Kestner single-effect climbing film evaporator, and the apparatus has been brought to such a state of perfection that the results are very satisfactory.

It has been ascertained that 1 kg. of slag contains about 550 calories, or 1000 kg. would contain 550,000 calories, and after allowing for loss by the heat remaining at 100 deg. C. and the heat in the water absorbed by the slag, estimated at 50 per cent., the net value of 1000 kg. would be 490,000 calories which a further allowance for working loss brings down to some 367,-500, which is equivalent to 590 kg. of steam.

In actual practice more than 740 kg. of water have been evaporated by 1000 kg. of furnace slag, and the average efficiency of the evaporator is approximately 91 per cent; but even at 80 per cent, the pure steam which could be used for turbines amounts to 472 kg., which, with a steam consumption of 13 kg. per horse power is equivalent to 36 horse power per 1000 kg. of iron slag.

Of course, in estimating the economy, the cost of the plant and labor have to be taken into consideration, and when the steam thus generated is used in a low-pressure turbine it is estimated that with a 1000 k.w. plant working at 75 per cent load, the generation of one k.w. would cost 0.32d. as against 0.48d. with a high pressure steam plant and coal at 14s. 6d. a ton, showing a saving of 0.16d. per k.w. in favor of the slag plant—a difference which is calculated to amount to about £4,300 a year at the works in question.

A New Thermopile

The practical difficulties hitherto encountered in the production of a thermopile capable of yielding an efficient and useful supply of electrical energy have been such that the instrument has been almost lost sight of amongst practical men for many years. It has remained for Johannes Marschall, of Dresden to produce a thermopile in which the old difficulties have to a very great extent been overcome, and which promises to be a serviceable source of current to small consumers of electrical energy. In the Marschall pile the positive elements are made of a special alloy of low resistance and high E. M. F., whilst the negatives are of con-

stantan, an alloy of copper and nickel, the junction being made with electro-deposited copper. Five such pairs in series form one section, and the requisite number of sections are arranged in an annular frame with the heated junctions on the inside and the cold junctions on the outside. The required output is obtained by employing a sufficient number of rings arranged in a central heating tube.

But a leading feature of Herr Marschall's apparatus is the furnace which acts as a gas generator in which the gas produced from coal or other suitable fuel is conveyed to the central heating tube, where, admixed with a plentiful supply of air, it undergoes perfect combustion. In the annular space on the outside of the rings of sections cold air is made to circulate at a speed sufficient to maintain the required temperature. Experiments with a pile consisting of ten sections working with the difference of 300 deg. C. between the hot and the cold junctions show an E. M. F. of 0.03 volt per pair.

On this basis it is estimated that a pile containing 1000 pairs would give 1.5 kilowatts at 35 volts, and would measure about 3 ft. in diameter by 7 ft. in length. A pile giving an output of about one kilowatt has been at work for some little time in Dresden, and so far no deterioration has been observed in regard to resistance at the junctions. If the claims which are put forward for the efficiency of this pile should prove valid, as appears probable, the apparatus will be very serviceable for lighting and small power installations, particularly in country districts remote from any power station. There is a growing demand for such an apparatus. But at present we have no information as to either capital outlay or working costs.

Revised Engineering Standards Specifications

The British Engineering Standards Committee has recently issued a report (No. 68) revising the specifications for the resistance of steel conductor rails for electrified railways. The resistance is to be stated in terms of a rail of the same material as the conductor-rail having a length of 1 yd. and weighing 100 lb. Conversion tables for resistances measured at a given temperature in rails of other weight are appended, together with formulæ for ascertaining in terms of the new standard the equivalents of the resistances of rails expressed in terms of copper, as formerly.

Specification No. 65 provides that pipes hitherto known as "stoneware" pipes shall be described as "salt-glazed ware" pipes. There are two classes of these, viz., "Standard Pipes," made to comply with the specification, only a certain percentage of which need be actually tested by hydraulic pressure, and "Standard Tested Pipes," every one of which must undergo hydraulic test.

All pipes complying with the B. E. S. specification are to have a standard mark.

Marine Oil Engines and Fire Risk from Sprayed Oil

The Board of Trade inquiry into the loss by fire of the small motor vessel *Scout*, on Loch Leven, last August, resulted in experiments being conducted by one of the board's surveyors which afforded some very instructive conclusions which fully justified the adjournment of the proceedings in order to ascertain whether oil projected from the flywheel of an engine of the type used on the *Scout* would ignite and cause the firing of the boat. The engine room and engine of the *Scout* were reconstructed as nearly as possible, and it was found that when running at 450 r.p.m. any oil that was in the bilge was thrown by the flywheel on to the exhaust pipe. If it were pure lubricating oil it did not ignite from contact with the exhaust pipe, but was vaporized in dense smoke which could be ignited by a naked flame. When glowing points left by burned cotton waste were put on the hot exhaust the oil caught fire, but not readily. With oil of lower gravity and flash point, such as paraffine, in the bilge the spray from the flywheel took fire immediately on coming into contact with the hot pipe.

The court found that the fire which destroyed the *Scout* was so caused.

The danger to be apprehended from sprayed oil is not confined to small boats having engines fitted with flywheels, but extends to all highly heated pipes and machinery where oils of low gravity are employed.

Public Companies

Anderston Foundry Co., Ltd.:

A final dividend of 15/6d. per share is recommended, making £1 per share for the year, less income tax. £40,984 is placed to depreciation and £10,000 withdrawn from the reserve fund four years ago are replaced. The dividend for the previous year was 12s. per share.

British Electric Traction Co., Ltd.:

A dividend is recommended of 3½ per cent on the 7 per cent non-cumulative preferred stock, as well as a full dividend on the 6 per cent cumulative preference stock. £50,000 is carried to reserve.

Marconi Wireless Telegraph Co., Ltd.—The ordinary general meeting was held July 21 when Commendatore G. Marconi, who presided, said he was afraid the report and figures had been somewhat disappointing to the shareholders; but, from the criticisms he had heard and seen, he judged that the report and the figures it contained had not been correctly apprehended. The reason why the directors recommended a final dividend of 10 per cent was the fact that the large sum of £142,726 5s. 11d. carried forward at the end of 1912 was carried forward for the purpose of averaging dividends after placing £100,000 to special reserve account. Some of the remarks during the discussion were distinctly of an acrimonious character; but the general feeling of the meeting may be gauged from the almost unanimous expression of confidence in the chairman and the board which followed the offers of resignation by the chairman and the managing director.

Market Prices—August, 1914

The official exchanges being closed, prices are not fixed, and can only be taken as representing private transactions and liable to change at any time. Those given below must be taken with all reserve, and show merely that, owing to precautionary measures, the possibility of violent fluctuations has been avoided.

The London Metal Exchange, after being closed from July 30, reopened from Aug. 18 from 11:30 a. m. until 12:30 p. m., and has been so opened since, but dealings and the making of prices were prohibited, and press publication forbidden.

	£. s. d.
Aluminum ingots, ton lots	85. 0. 0
Copper sulphate, cwt	17/6 to 18. 6
Caustic soda, 70%, cwt	9/9 to 10. 3
India Rubber, Para, fine, lb	2.10
Petroleum, Russian spot, gal	9¼
Lead, ton	21. 0. 0
Copper	58. 2. 6

Best selected copper was quoted as follows during the month:

	£	£	
July 31st	60	-61	per ton
Aug. 4th	60	-61	" "
" 7th	64½	-65½	" "
" 11th	65	-66	" "
" 14th	64	-65	" "
" 18th	63	-64	" "
" 21st	61	-62	" "
" 25th	60	-61	" "

Synopsis of Chemical and Metallurgical Literature

Gold and Silver

Nipissing Mill and Metallurgical Practice.—A discussion by **Mr. G. H. Clevenger** at the Salt Lake meeting of the A. I. M. E. of a paper previously presented to the Institute by Mr. James Johnston. After outlining the status of metallurgical practice at Cobalt prior to the researches by the Nipissing company, Mr. Clevenger states that it was the determination of the Nipissing consulting metallurgists to treat all ore by a hydrometallurgical process and that nothing but refined silver was to leave the premises. The middle ground involving concentration and cyanidation did not appear attractive. "Generally you are attempting to operate a concentrator and a cyanide plant with neither up to full efficiency." Concentration in combination with cyanidation should be adopted only as a last resort.

The results of preliminary tests indicated that a cyanide plant would be most advantageous. The use of mercury in the low-grade mill was not attractive, and the plan of grinding the whole ore, native silver, dyscrasite, etc., fine enough so that all the silver could be dissolved by cyanide, was finally adopted. Usually when metallic gold and silver occur in ores that are to be cyanided, amalgamation or concentration are resorted to; but in this case the native metal was finely ground for cyanidation. This is a point on which there may be a strong difference of opinion, and which must be determined by conditions.

The author points out that the idea of using a preliminary treatment involving the use of aluminium and caustic soda on precious-metal ores, such as is done at Nipissing, is not new. It was suggested by W. H. Walker in a note on the electrometallurgy of gold, published in the *Transactions* of the American Electrochemical Society, volume four, 1903. This preliminary reduction may not be economically feasible on all ores, and the author urges caution in its adoption. Thus in the Cripple Creek district, where roasting is cheaply done, the wet reduction process might not be profitably adopted, but where roasting cost on telluride ores was high the wet reduction method would merit consideration. In some cases wet reduction might form products that would interfere with cyanide treatment or cause a high cyanide loss. Again, preliminary treatment with caustic soda alone has proven valuable.

Although precipitation by aluminium dust was finally adopted at Nipissing, the author is not convinced that zinc precipitation would have been impossible. The application of aluminium dust precipitation elsewhere must be considered cautiously. Probably its future use will be confined to special cases. One of the difficulties encountered in using this precipitant is the long period of violent agitation necessary, due to a coating of the oxide and stearine, the latter being used in the manufacture of the dust.

The author gives consideration to the relative merits of zinc and aluminium as precipitants and discusses the claim for cyanide regenerated by the use of aluminium. He points out also the chemical value of zinc in cyanide solutions, as potassium zinc cyanide, and the gradual regeneration of cyanide in alkaline cyanide solutions that have been precipitated on zinc.

Descriptive Technology of Gold and Silver Metallurgy.—A paper presented at the Salt Lake meeting of the A. I. M. E. by **Mr. A. W. Allen,** in which the author deals with some inconsistencies of expression used by technical writers and points out fallacies in the presentation of metallurgical results. On the subject of "extraction," the point is made that "extraction and recovery are terms which are not necessarily interchangeable and the time is ripe for due recognition of the fact." The author objects to certain loose methods of calculating and reporting recoveries in metallurgical processes, and points out the necessity of clarity of statement so that comparisons can be made between operations at different mills.

The following definitions are suggested, and formulae given for obtaining the desired results:

The assay or theoretical extraction is the amount of metal which is indicated by assay results as having been removed from the ore during treatment.

Where a = the assay of feed,
z = the assay of residue, and
t = the tonnage represented,

then $\frac{100\,(a - z)}{a}$ = *percentage assay extraction.*

and $\frac{a_1t_1 + a_2t_2 + a_3t_3 + \dots}{t_1 + t_2 + t_3 + \dots}$ = average feed assay = A,

and $\frac{z_1t_1 + z_2t_2 + z_3t_3 + \dots}{t_1 + t_2 + t_3 + \dots}$ = average residue assay = Z.

then $\frac{100\,(A - Z)}{A}$ = *average assay extraction percentage.*

The actual extraction indicates the amount of metal recovered from the ore and isolated either as bullion or in other concentrated form. Such actual extraction is estimated by the direct valuation of the bullion and the statement of return from smelter or buyer showing actual metal content in concentrated product, upon which sale was effected.

Where M = the amount of metal in bullion, concentrate, or precipitate,
T = the tonnage milled,
t = the tonnage of concentrated product removed, and
Z = the average actual residue assay,

then $\frac{100\,M}{M + Z\,(T - t)}$ = average actual extraction percentage.

The actual recovery can only be based on the direct valuation of bullion, and the term is only available for use when the bullion produced is approximately the same market value, *per se*, as the contained gold and silver.

Where M = the amount of metal in bullion,
T = the total tonnage, and
Z = the average residue assay,

then $\frac{100\,M}{M + TZ}$ = *average actual recovery percentage.*

In the statement of working costs, the author urges the segregation of working cost from general expense, and the differentiation between the cost of repairs and renewals. In the statement of construction costs he suggests the exclusion of all sums paid for wearing parts, these being segregated in a suspense account and charged out as operating expense. Attention to these details will prevent large fluctuations in costs and avoid false impressions.

Copper, Lead and Zinc

Unit Construction Costs of the Arizona Copper Company's Smelter.—Probably no paper presented at the Salt Lake meeting of the A. I. M. E. received more commendation than did that of **Mr. E. Horton Jones,** in which unit costs of smelter construction were given. The paper was spoken of as a classic of its kind. Naturally no abstract can be given, and reference must be had to the original paper published in the July *Bulletin* of the Institute. The actual figures are of interest primarily to smelters, but all classes of metallurgists will be interested in the manner of presenting these cost data, and will gain a great deal by studying the article. The subject is presented under five heads: unit costs, comparative costs, composite costs, wage scale and raw material

prices. Each cost item is described, and numerous drawings illustrate the types of construction.

Nodulizing Blast-Furnace Flue-Dust.—Experience with a 6-ft. by 60-ft. rotary, oil-fired kiln is given in the July *Bulletin*, A. I. M. E., by Mr. **Lawrence Addicks.** Preliminary experiments in a 2-ft. by 20-ft. kiln indicated a fuel consumption of 50 gal. of oil per ton of dust nodulized. Excellent nodules were formed and rings or accretions were absent. In the larger kiln in actual operation, fuel consumption was greatly reduced and rings showed a marked tendency to form. A first-class smelting product could be made with an oil consumption of 12 gal. per ton. The inclination of the kiln was $\frac{3}{8}$ in. per foot, and the speed $1\frac{1}{2}$ r.p.m. Capacity varied: with a clean kiln it was possible to nodulize 75 tons of dust in 24 hours; a choked barrel reduced the capacity half, but regular operation delivered an average of 50 tons per day, including all delays. Experiments with coal firing, operating after the manner of a gas producer, was a failure owing to irregularity in the temperature at the mouth of the kiln. Coal-dust firing was not tried as it gives too high a temperature for nodulizing. The author believes that kiln-nodulizing is worthy of wider use, but suggests that its applicability can be determined only by experiment. "The crux of the whole matter lies in cost of fuel."

Basic-Lined Converter Practice at the Old Dominion Plant.—Conditions at the Old Dominion smelter make it necessary to crowd the converter capacity to its limit, and interfere with the systematic operation of the converter. Mr. **L. O. Howard** gives the following record of converter operation, in a paper presented at the Salt Lake meeting of the A. I. M. E.

Commenced blowing	Jan. 6, 1913
Taken off stand for patching	June 27, 1913
Total blowing time	2,689 hr. 40 min.
Total number of blows made	664
Average time of blow	4 hr. 3 min.
Tons matte charged	18,157
Average copper content of matte	43.9 per cent.
Average time blowing one ton copper	22.5 min.
Total copper made	7,250 tons
Average copper per converter hour	2.66 tons
Average air used per minute	9,000 cu. ft.
Average blast pressure	13.3 lb.
Ore fed	3,304 tons

Average Slag Analysis	Per Cent.	*Average Matte Analysis*	Per Cent.
Cu	2.5	Cu	43.9
SiO_2	22.7	Fe	28.8
Fe	52.1	S	22.6
CaO	0.8	Ins	0.4
Al_2O_3	1.6		

The author describes a difficulty encountered in the closing of the converter mouth due to cooling of the charge when it was necessary to pour from the converter directly into molds at a time when the casting machine was out of commission. Various means were tried for removing the incrustations, but none proved effective until a specially designed collar puller was adopted. This device is lowered into the mouth of the converter from the crane. On lifting, a cutting tooth is forced into the incrustation, loosening it until large pieces can be removed.

Experience with the formation of monolithic magnetite lining on the basic brick is also described.* Following is the method used at Old Dominion for applying the magnetite coating: Into a new converter previously heated by coal and coke, charge about 12 tons of molten matte and blow for about 3 hours with silica. Then lower the temperature by the addition of about 4 tons of cold hood cleanings and blow for a short time, when the magnetite will be spread evenly over the interior. More matte and just enough silica to flux the iron therein contained are then added, and the charge finished in the usual manner. The magnetite lining is then maintained by attention to the temperature of converting.

Smelting Lead Ores in the Blast Furnace.—In a paper on this subject by Mr. **Irving A. Palmer,** published in the July *Bulletin* of the A. I. M. E., the author calls attention of the modified policy of one of the largest lead smelting companies regarding publication of details of its technical operations, and commends the abandonment of secrecy in this respect. The paper covers many details of lead smelting, and the original must be consulted to get the greatest benefit. Of first importance in the progress in lead smelting in recent years is the adoption of sinter-roasting, as in Huntington-Heberlein pots and Dwight-Lloyd continuous machines. Second in importance is the general use of mechanical methods in handling materials. The bag house has been more generally adopted, and larger furnaces are being built. Water jackets are of soft steel instead of cast iron. Mechanical feeding has been more generally adopted, and the charges are more thoroughly mixed than formerly. In discussing the effect of different ingredients in the charge and the formation of slags and mattes, the author points out the necessity of looking for metal losses elsewhere than in the slag, and suggests that lead is a very elusive metal when in the form of fume.

The Bag House in Lead Metallurgy.—In a paper presented at the Salt Lake meeting of the A. I. M. E., Mr. **L. Douglass Anderson,** superintendent of the Midvale smelter of the U. S. Smelting Co., discusses the complete bag house system adopted at that plant in order to minimize damage to agricultural crops in Salt Lake valley. Both blast furnace and roaster gases are thus collected separately. The former present no difficulties, but the latter are hot and contain more or less sulphuric acid, and must be cooled and neutralized. The importance of cooling cannot be underestimated if metal recovery is to be complete. Cooling can be accomplished by passing the gases through thin metal flues, by water sprays and by dilution with external air. Neutralization is done by introducing lime, zinc oxide, or other suitable base into the flues.

The introduction of the bag house has resulted in the accumulation of many elements, such as arsenic, cadmium, tellurium and selenium, which formerly escaped, but which now increase in quantity if a closed circuit is maintained for any length of time by resmelting bag-house residues. At Midvale the arsenic is allowed to build up until the dust is rich enough for treatment in arsenic furnaces for the recovery of white arsenic.

The author mentions the experience with Dwight-Lloyd machines, and the bag-house fires which resulted from the distillation of elemental sulphur into the flue gases. This condition was marked in damp weather and disappeared in warm dry weather. Various schemes were tried to avoid this condition, but they were ineffective. Finally the use of these machines was limited to sintering pre-roasted matte and ores low in pyrite.

Lead-Matte Converting at Tooele.—A modification of the usual method of converting leady matte has been adopted at the Tooele smelter of the Internation company. The process was described in a paper read by Mr. **Oscar M. Kuchs** at the Salt Lake meeting of the A. I. M. E. At first it was endeavored to convert copper-lead matte in the usual manner, with the direct addition of silicious fluxing ores; but bag-house troubles developed in the form of acid spots on the

*Originally described by Wheeler & Krejci, *Bulletin* A. I. M. E., Dec., 1913. See also this journal, Feb., 1914, p. 138.

bags, resulting in their ultimate destruction. This meant that either the converter fumes must be neutralized by CaO or ZnO, or the production of a fume in itself sufficiently alkaline to prevent the deposition of free acid in the bags. Hence the method was changed, and molten matte directly from the blast furnaces is now blown without the addition of silicious flux, to the almost complete elimination of the lead, and to the production of copper bullion. The lead fume is collected in the bag house, and the copper bullion and heavy iron slag are transferred to converters blowing copper matte. This reduces the copper oxide formed in the first blow of the lead-matte charge, and utilizes the value of the iron slag for fluxing silicious ores. The final slag from the copper converters is then transferred molten to a reverberatory copper furnace. This system has greatly improved conditions in the bag house.

Losses of Zinc in Mining, Milling and Smelting.—In the symposium on zinc metallurgy at the Salt Lake meeting of the A. I. M. E., Messrs. **D. A. Lyon** and **S. S. Arentz** presented a paper in which they discussed the present losses of zinc and the probable methods for reducing such losses. It is stated that probably less than 50 per cent of the zinc mined reaches the form of spelter. The methods of beneficiating and smelting zinc ores are briefly discussed, and the possible future sources of zinc are given, as follows: Present waste in concentration processes, waste in slags of lead and copper smelters, low-grade carbonates, and micro-crystalline ores of zinc, iron and lead.

Ammonia-Carbon Dioxide Process for Complex Zinc Ores.—Another paper in the zinc symposium was that of Mr. **S. E. Bretherton,** who advocated the use of the ammonia-carbon dioxide process for the treatment of zinc ores containing precious as well as other base metals. Briefly the process is as follows: Grind the ore, roast, regrind, leach zinc with ammonia and carbon dioxide, precipitate copper from the zinc solution, distill ammonia and carbon dioxide from the solution, thereby precipitating basic zinc carbonate which can then be calcined to oxide. The precipitated copper can be added to the residue, which is then ready for smelting. The basic zinc carbonate can be smelted, or converted into chloride for use as a wood preservative. If the oxide can be made pure white, it can be used as a pigment. The author concludes his paper with a detailed report on test runs in an experimental plant.

Chemical Engineering.

Ammonia Analysis.—In an article by **E. Stach** in *Glückauf* of Aug. 1, 1914,, various new apparatus are described for determining and recording the pressure, speed, and the density of gases and vapors, besides an instrument for determining the ammonia content in liquids. The principle of the latter instrument is that when ammonia is decomposed by hypobromites or hypochlorites, nitrogen is developed in gas form in a quantity proportional to the ammonia to be determined. The equation for an ammonium chloride solution with sodium hypobromite $3NaBrO + 2NaOH + 2NH_4Cl = 2N + 2NaCl + 5H_2O + 3NaBr$. In order to record automatically the result of the analysis the nitrogen set free is measured by the instrument shown in Fig. 1. At *a* the liquid containing the ammonia enters. At *b* the hypobromite is syphoned off. In the measuring vessel *cd* the liquids are kept on a certain level. Through *e* water enters into *fg* and compresses the air in *g* to a pressure which depends on the height of the syphon *h*. This compressed air acts on the liquids in *c* and *d* whereby they are forced into the mixing vessel *i*. Since the compressed air cuts off *k* simultaneously, the nitrogen set free in *i* must pass below the bell *l*, the motion of which is transmitted to the recording drum.

Sulphuric Acid Towers.—In the *Chemiker Zeitung* of July 30 Dr. **Georg Schliebs** emphasizes that if sulphuric acid towers are to be substituted for lead chambers, they should be designed and operated ac-

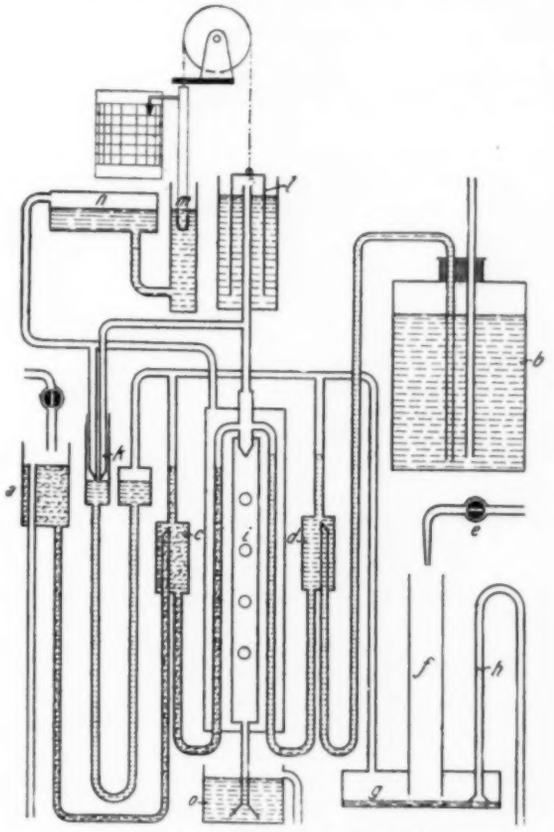


FIG. 1—AMMONIA ANALYSIS

cordingly, but this is usually not the case. In the first place, there is not the same opportunity for the gases of getting mixed. In a lead chamber of 1000 to 3000 cubicmeters content the gases remain for half an hour or an hour in continuous motion and mixing, concentrated gases coming in contact with gases which have been already become diluted and so on. Through a tower of 100 to 300 cubicmeters content the gases pass in a few minutes. While there is a perpetual dividing up and reuniting of the gas currents, there is never an opportunity of fresh gases and of diluted gases coming together. In the second place a lead chamber is able to get rid quickly of any excess of heat by simple radiation. The tower has a much smaller radiation surface, moreover, the tower fillings act as a storage or reservoir of heat. Further in a lead chamber the gases are repeatedly heated and cooled, which is impossible in a tower. The author thinks that these disadvantages of the tower can be overcome by the very simple remedy of providing behind the tower an "equalizer" ("Ausgleicher"), that is a vessel in which the acid is removed from the gases, while the gases which are now more dilute and have been cooled may be returned by a special pipe line back to the entrance of the tower so as to pass through it again. He obtains in this way a forced mixing of dilute and of fresh concentrated gases. Further the reaction heat is gotten rid of in a simple way by air or water-cooling. Temperature differences are produced since the warm gases are cooled in the equalizer and are heated

again in their next passage through the tower. The output of the different towers and of the whole system may be regulated by this method within wide limits. The towers are better utilized and the expensive supply of acid running down over the filling may be largely reduced. Disturbances in operation and variations in output and temperatures may be equlized before they reach the final towers.

Radium in Carnotite

Determination of the Radium: Uranium Ratio in Carnotites.—The increasing importance of carnotite as the largest known source of radium has made the accurate determination of the radium: uranium ratio in that mineral of the greatest importance. Hitherto investigators have found deviations from the normal ratio, as observed in pitchblende, and the results have usually been low. Hence the impression has gained ground that carnoties are, as a rule, anywhere from a few per cent to 30 per cent lower in radium than would correspond to the uranium content. In order to investigate this matter more carefully, Messrs. **S. C. Lind** and **C. F. Whittemore,** of the Denver office of the Bureau of Mines, conducted a research, the results of which are published in the current issue of the *Journal* of the American Chemical Society. Their work is of great importance to the American radium industry, for they establish the fact that the ratio of radium to uranium in carnotite is identical with that of pitchblende. Their paper describes methods of procedure and gives data on many determinations. Following is a summary:

1.—Samples of carnotite representing *large* quantities of ore (a few hundred pounds to several tons) show a Ra:U ratio identical with that of pitchblende, 3.33×10^{-7}, which is also in accord with the value calculated from radiation data.

2.—Samples from *small* quantities (hand specimens up to a few pounds) tend to exhibit abnormal ratios, in one instance as low as 2.48×10^{-7}, and in another as high as 4.6×10^{-7}.

3.—The most plausible explanation for these ratios seems to be one of "transposition" of radium within an ore bed, producing local differences which are equalized in large samples.

4.—The "emanating power" of carnotite appears high and varies from 16 to 50 per cent.

5.—In order to obtain concordant results by the Boltwood emanation method, it was found desirable to determine the emanation liberated by solution in the same sample from which the emanating power had just been determined, thus making the two determinations strictly "complementary."

6.—Radium may be easily determined by the emanation method in one operation either by solution or by ignition from tubes in which it has been sealed for one month to reach equilibrium.

7.—In contrast with the successful solution or ignition methods for de-emanating carnotite, fusion with carbonate, and also the fusion and solution method both gave low results and were abandoned.

Corrosion.

Corrosion of Condenser Tubes.—A very suggestive article on the corrosion of condenser tubes is contributed to the September issue of the *General Electric Review* by **E. Bate,** of the New South Wales Government Tramways in Sydney, Australia. The author gives a review of his own experience with pit-hole corrosion. With Rhodin he distinguished between balanced and unbalanced alloys. "Particles of the two constituents of the alloy, infinitesimally close together, will have each a definite solution potential. If these solution potentials balance, then the minimum rate of corrosion is obtained, for if they do not balance, local currents are set up and electrolytic corrosion assists the purely solution or oxidation corrosion. On this theory, and by using the heats of oxidation and molecular weights of copper and zinc, the author arrived at the result that 70 per cent. Cu and 30 per cent. Zn is the best alloy of these two metals." The British Admiralty specifies a mixture of 70 per cent. Cu, 29 per cent. Zn and 1 per cent. Sn.

Its suitability for plants using sea water is, in the opinion of the author, well established. When pit-hole corrosion occurs, however, it is of a local character and is ascribed by the author to local action due to an electronegative particle on a surface positive to it. There seem only two ways in which such a condition can be set up: (1) by segregation in the alloy; (2) by a deposit of electronegative particles on the tube surface. That the second assumption is correct is, at least in his own case, the chief point of the author's discussion and his arguments in this respect are as follows: First, as to the time which it takes for the tube to become pitted completely through he finds that failures start to take place within a month or two after the condenser is put in service, and the average failures per week gradually increase to a steady average rate of failure, with heavy failures now and again. In some cases the trouble may cease after a few months, and the engineer usually concludes that corrosion was due to faulty tubes, which have been eliminated. In several cases the author has found that about the time when failures ceased, some certain treatment of the condensers had been started, which the engineer generally did not connect in any way to the improved conditions. He emphasizes the fact that it is possible to stop failures by methods whose only effect would be to prevent the possible deposit of electronegative material in the tubes, and, furthermore, that the effect is noticeable very rapidly, which points to the fact that corrosion is a phenomenon whose action is very rapid. Further "if corrosion is due to a deposit, then, undoubtedly, we can expect with confidence that the majority of holes will be in the lower half of the tube. This anticipation is most strikingly verified as a result of the author's observations." Of 468 tubes the author found that only 21 had a corrosion hole in the upper half of the tube, the remainder were in the lower half. That corrosion of the tubes under notice took place on the bottom half of the tube has been corroborated by other engineers whose condensers suffered in the same way. Since, therefore, the very strongest grounds were present for suspecting that a dangerous deposit was being left in the tubes, it became important to determine from what source this deposit came.

"The author's attention was directed to the corroding cast iron of the circulating system and condensers as a source of troublesome deposit for the following reasons: Although the circulating water brought through the condensers in question is always very dirty, certain condensers taking the same water have been free from trouble. If, therefore, we consider the water at intake in the harbor as free from deleterious material, the troublesome particles must come from the metal in contact with the water on its way to the condenser. Cast iron, unless carefully protected, corrodes severely when exposed to the action of sea water, and as cast iron is a so-called alloy of carbon and iron with traces of other impurities, the products of corrosion will be mainly oxide of iron and carbon. Carbon is, as previously pointed out, strongly electronegative, and, therefore, of just the

nature to cause the trouble experienced. The condensers under particular observation, which gave very serious trouble, were provided with 22 copper stays between tube plate and water box cover at each end, and these copper stays had cast-iron sleeves to form distance pieces between tube plates and covers. There were thus 44 cast-iron distance pieces in the water space of the condenser, all of which were found to be badly corroded, especially close to the tube plate, where they were in close contact with the gun-metal.

To test this theory, the cast-iron distance pieces were removed, and gun-metal distance pieces substituted, while, at the same time, the cast-iron surfaces in contact with circulating water were all cleaned and painted with a protective coating. "The measures above outlined were soon productive of marked diminution in the number of tube failures in these condensers, and it can be definitely stated that, up to the present, no tube put in the condensers since the alterations were made has failed." Stations that take circulating water to the condensers, or to the circulating pump intake in concrete or brick ducts, and use either short cast-iron or entirely gun-metal intakes, should, therefore, not suffer to any appreciable extent from tube corrosion. At the White Bay power-house this policy can be pursued, as the circulating water ducts are entirely of concrete, and the short intake is of gun-metal, the pump body and impeller being of a yellow metal mixture. Inquiries have elicited the information that several plants, which have been free from trouble, have consistently protected their cast iron on general grounds without any idea of thereby preventing the corrosion of condenser tubes. "The author trusts that if the logic of his theory is sound, the result will be a greater confidence in installing large condensing plants, and less anxiety as to the possibility of serious and expensive trouble. It should lead to a modification of those conditions under which large stations draw supplies of sea water through considerable lengths of cast-iron piping, often quite untreated internally, and thus liable to continuous corrosion. The suitability of the Admiralty tube for plants using sea water, when supplied by good makers, is, in the opinion of the author, well established, but tinning of the tube seems unnecessary and dangerous."

Rutile.—Virginia produced all the American output of rutile in 1913, according to the United States Geological Survey, the deposits being located at Roseland, Nelson County. During the year the company which controls and works these deposits produced 305 tons of rutile, valued at about $49,000. A large part of the rutile produced in 1913 was used in the manufacture of titanium carbide electrodes for arc lamps. A part of the ilmenite found in the deposits and separated by means of amagnetic separator has been sold for use in making electrodes for electric lights, and the experiments with the electric furnace point to the possible use of ilmenite in the direct production of tool steel.

Tungsten.—The tungsten resources of the United States are probably considerably larger than have been generally realized. Many new deposits have been discovered in various parts of the Western States, according to the United States Geological Survey, and, should prices advance, it is probable that the output could soon be increased much above the record year of 1910, when 1821 tons were marketed. Most of these new discoveries are not sufficiently developed to show how large an output can be expected from them; but it is probable that some will prove to be of considerable extent, and one or two new large producers would make a noticeable difference in the American market.

Recent Chemical and Metallurgical Patents

Iron and Steel

Briqueting Fine Ore.—An improved method of briqueting fine iron ore, flue dust and the like, has been patented by **Walter Mathesius,** of Charlottenburg, Germany. The invention consists in the employment of a binding medium which will react with a part of the iron in the material to be briqueted. Alumino-silicates of a highly basic nature are mixed with ferric hydroxide and water, and this binding medium then mixed with fine ore. If the addition of ferric hydroxide has not exceeded a certain limit, the binder will react with further quantities of ferric hydroxide or oxide, and yield products having the properties of a cement. The binder should be mixed with the ore in as fresh a state as possible. The quantity of ferric hydroxide in the binder should not exceed one molecule for each three molecules of the bases contained in the alumino-silicates. From one to two per cent of the alumino-silicates is sufficient to form firm briquets. Portland cement blast furnace slag or like products of calcination or fusion containing the necessary quantity of lime can be used as the basic alumino-silicates. Burnt lime also may be used, but in that case the binder must be formed by grinding the lime with fine iron ore in water, and after heating to accelerate the reaction between iron oxide and lime, mixed in a fresh state with the material to be briqueted. The whole is then molded and allowed to set. In order to lower the fusing point of the briquets and thereby prevent disintegration before fusion, certain addition agents may be used, such as the oxides of magnesium, strontium or barium, or small quantities of titanic acid. (1,104,124, July 21, 1914.)

A Method of Incorporating Titanium into Iron has been patented by Mr. **Auguste J. Rossi,** of Niagara Falls, N. Y., and assigned to the Titanium Alloy Manufacturing Co., of New York City. Relatively high temperatures, say 2500 deg. C. or higher, are required for the production of titanium-iron containing relatively high percentages of titanium, say 10 per cent. The inventor has discovered, however, that lower-grade titanium irons, containing say from 5 to 1 per cent of titanium, can be made at temperatures of the open-hearth or blast furnace, say from 1500 to 1700 deg. C., provided there be present, during some stage of the operation, manganese in the elemental state. He cites the fact that titaniferous iron ore containing as high as 40 per cent titanic acid, when smelted in the usual manner, will yield iron containing little or no titanium, but when smelted with manganese in the charge, the resulting iron will contain as much as 5 per cent of titanium. The invention can be practiced by incorporating into any approved furnace charge, comprising titaniferous iron ore, fuel and fluxes, oxide of manganese in the form of manganiferous iron ore, so that nascent manganese will be present during the reduction. The titaniferous iron ore should contain at least 3 per cent titanic oxide, and manganese should be present in quantity not less than equal to 10 per cent of the titanic oxide. (1,104,317, July 21, 1914.)

Ore Reduction.—A novel proposal for the reduction of iron and other ores that are not volatile at a temperature of 800 deg. C., is contained in a patent granted to **Buenaventura Junquera,** of Oviedo, Spain. In brief, it is proposed to fine-grind the ore, fluxes and carbon for reduction, and feed the mixture at one end of a rotary furnace. The furnace is fired from the opposite end with pulverized fuel. The reduction of the pulverized mineral in contact with the reducing

carbon is very rapid and occurs in the front end of the furnace at a temperature of 600 to 800 deg. C. When the mixture of reduced metal and flux reaches the high-temperature zone of the furnace (1500 to 1600 deg.) fusion occurs and the slag and metal are discharged into a receiver. The inventor claims that by his process iron ore can be converted in twenty minutes into molten iron containing 0.10 per cent carbon. The consumption of fuel for converting ore of 50 per cent iron into metal is about 1000 kg per ton of metal obtained, of which about 600 kilos is used for reduction and 400 for combustion. (1,102,339, July 7, 1914.)

Preparation of Flue-Dust and Fine Ore for Smelting.—In order to agglomerate fine ore and flue-dust and make a product suitable for charging into a blast furnace, Mr. **William Cooper**, of Denver, Col., proposes to inject into piles of such material a liquid hardening medium, such as a thin solution of cement. The grout thus formed is allowed to harden, after which the pile is broken into lumps. The binding material is forced into the pile through perforated pipes driven to the bottom. (1,103,400, July 14, 1914.)

Gold and Silver

Preparation of Refractory Ore for Cyaniding.—The wet desulphurizing process used at the Nipissing mill, Cobalt, Ontario, whereby the refractory silver sulphide, sulpharsenide and sulphantimonide minerals are decomposed and rendered amenable to cyanidation, depends in principle on contact of the pulverized ore with aluminium in alkaline solution. A description of the work at Nipissing appears elsewhere in this issue. In a patent recently granted to Mr. **Charles Butters**, the process is outlined as follows: "The invention is based on a reaction which it has been found occurs when sulphide gold and silver ores, tellurides, and similar ores associated with, or not associated with, arsenic, antimony and the like are brought into intimate contact, such as by agitation or otherwise with certain metals such for example as aluminium, zinc, tin or palladium, in any convenient form, but preferably as metallic surfaces, in the presence of caustic soda or other caustic alkalies, either hot or cold, which results in such ores being decomposed and the metallic gold and silver being freed from combination with the sulphur or the like, whereby they are in condition to be readily attacked or dissolved by potassium cyanide or other suitable solvents. * * * Under these conditions an electric current is set up between the aluminium and the ore under treatment, the aluminium acting as the anode and the ore as the cathode, which latter, probably principally through the agency of nascent hydrogen, is then split up into its component parts, and the precious metals left free to be acted on by cyanide or other suitable solvents." Equations showing the effect on argentite are as follows:

$$2Al + 2NaOH + 2H_2O = Na_2Al_2O_4 + 6H$$
$$6H + 3Ag_2S + 6NaOH = 3Na_2S + 6H_2O + 6Ag$$

For gold telluride, the equation is:

$$AuTe_2 + 2Al + 4NaOH = Na\,Al_2O_4 + Na_2Te + 2H_2Te + Au$$

It is gathered from the patent specifications that the process is of wider application than that now known to be used at Nipissing. (1,103,346, July 14, 1914.)

Chlorination of Ores.—Frequent references have been made of late in technical literature[1] to processes for chloridizing low-grade ores containing gold, silver, copper and lead, according to methods devised by **N. C. Christensen, Jr.**, and **T. P. Holt**, of Salt Lake City, Utah, and to the mills utilizing such processes. In a patent recently granted to these men (Christensen assigning his interest to George H. Dern, of Salt Lake City) they disclose details of operation and furnace construction, practically as used at Park City, Utah, by the Mines Operating Co., under the direction of Messrs. Dern & Holt.

The preparation of the ore is accomplished by grinding, mixing with about 2 per cent of fuel, unless the ore contains fuel such as sulphides, mixing also with salt, and finally adding moisture varying from 5 per cent for coarse, non-absorbent ore, to 15 per cent for fine, absorbent material. The mixture is then roasted in a shaft furnace, such as illustrated in Fig. 1, in which air is forced through the charge from beneath, and in which certain zones are maintained as indicated in the figure. In this manner a counter-current flow of ore-mixture and air is achieved. The roasted ore is withdrawn from the bottom of the furnace and fresh mixture added from above. The roasting zone is always within the furnace charge and protected by roasted ore below and unroasted mixture above. The roasted ore is lixiviated with acidified water and the metal is precipitated from the solution as explained in previous articles to which reference has been made.

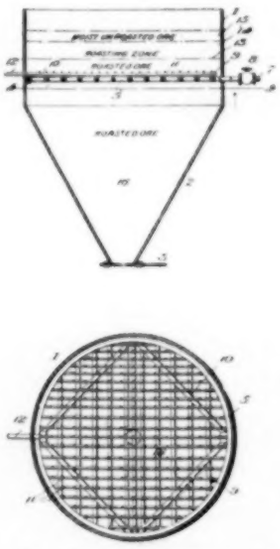


FIG. 1 — FURNACE FOR CHLORIDIZING-ROASTING

The furnace shown in the figure consists of a circular or square upper part 1 and a conical or pyramidal lower portion 2. The air-blast pipe 5 is disposed about the upper portion and connected with cross pipes, all having openings on their lower sides. A stirring grate 9 is placed just above the air pipes, and by its operation the roasted ore is gradually removed from the roasting zone and discharged through the gate 3 at the bottom. In starting the furnace, it is filled with roasted ore up to the level 13. A layer of live coals is then prepared and on this is charged the green mixture; the blast is applied, and the operations of discharging roasted ore and charging green ore proceed as desired. Gases from the furnace are dustless and are conducted to absorption towers to produce liquor for lixiviation. (1,107,240, Aug. 11, 1914.)

Slime Filter.—A new method of applying vacuum filtration to ore slime is disclosed in a patent granted to Mr. **Walter E. Trent**, of Reno, Nevada. As shown in Fig. 2 the filter consists of two wheel frames mounted on a shaft, with swinging filter pans or trays disposed between the spokes of the wheels, after the manner of a "Ferris" wheel. Each filter pan is connected with a source of vacuum through the pipe frames that constitute the spokes of the wheel which, in turn, communicate with the hollow central shaft. Feed is delivered to the filter pans through pipes that revolve with the frame and connect with an annular launder at one end of the shaft. Washes of water and solution can be applied as desired, and the filtered cake is discharged by automatically tipping the pans as they approach the point of discharge. As each pan

[1] This journal, Nov., 1913, pp. 605 and 657; Apr., 1914, p. 222; July, 1914, p. 431; Aug., 1914, p. 492. Also *Bulletin* A.I.M.E., July, 1914, p. 1699.

is weighted, it resumes its horizontal position after dumping, when it is ready to receive a new charge. (1,097,896, May 26, 1914.)

Another form of vacuum slime filter on which a patent has been granted to **George Ridgway,** of Kalgoorlie, Western Australia, consists of two tanks to hold the slime pulp and wash solution, filter frames through which the slime is filtered, and rocking arms the transfer the frames from one tank to the other after the successive functions of filtering and washing have been performed. During the passage back from the wash tank to the slime tank compressed air is admitted to the filter leaves and the slime cake is discharged. Automatic reversing gear and valve trips govern the operation of the filter. (1,103,080, July 14, 1914.)

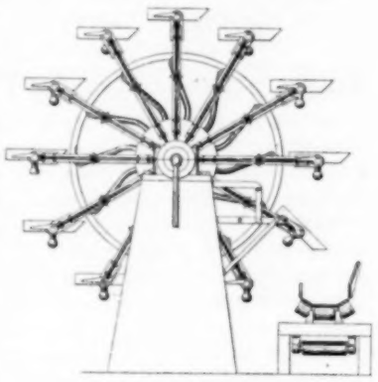


FIG. 2—VACUUM FILTER

Lead and Copper

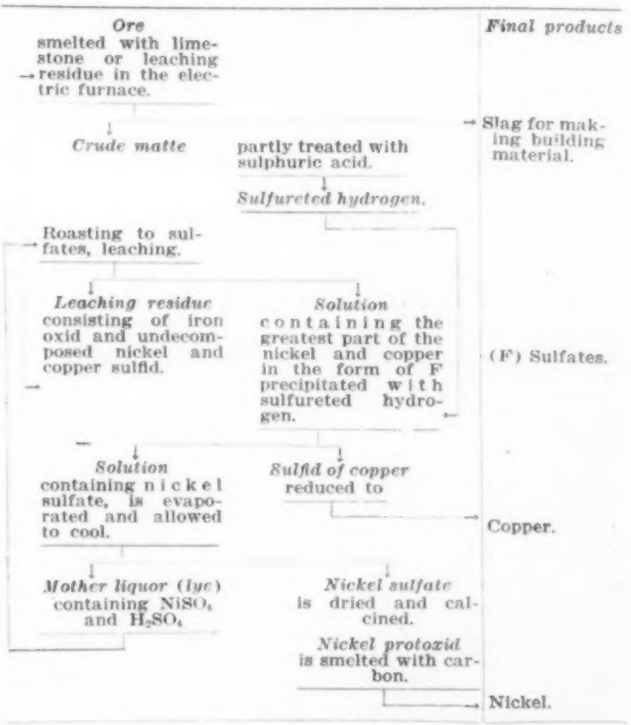
Refining and Desilverizing Lead Bullion.—An improved method of arranging and operating a plant for refining and desilverizing lead bullion by the Pattinson process has been patented by **William Thum,** of Hammond, Ind. According to this process, lead bullion containing silver is agitated with air or steam, and intermittently sprayed with water, with the effect of crystallizing the lead and leaving a liquid enriched portion containing the silver. The lead settles to the bottom of the kettle, while then enriched bullion floats above, as well as permeating the mass of lead crystals. The two portions are then separated, each being transferred in opposite directions through a series of kettles. The resulting desilverized bullion is cast for sale and the enriched portion for refining by electrolysis or cupellation or other form of refining. The transfer of the respective portions has hitherto been accomplished by raising the kettle being tapped, or lowering the receiving kettle, or by means of large ladles handled by cranes.

The present invention makes use of air pressure for the transfer of the products through the series of kettles, thus avoiding movement of the kettles and permitting a fixed arrangement. The kettles are constructed so that they can be removed from their settings in case of renewal or repair. (1,106,480, Aug. 11, 1914.)

Reducing Cuprous Chloride.—A patent has been granted to **Frederick Laist,** of Anaconda, Mont., for an improved method of reducing cuprous chloride in such a way as to regenerate the chlorine as a chloride salt suitable for reuse in chloridizing oxidized copper solutions. The method has relation to Mr. Laist's previously patented modification of the Hunt & Douglas method of leaching copper ores with sulphuric acid solution, containing also sufficient chlorine, in the form of a soluble chloride, to form the subchloride with the copper. Having dissolved the copper from an ore with the solution above mentioned, cuprous chloride is precipitated by treatment with sulphur dioxide. According to the present invention, in order to regenerate the chlorine therein contained for use on further lots of ore, the cuprous chloride is reduced with carbonate of calcium or sodium and carbon, whereby copper is reduced and the chlorine is combined with calcium or sodium. The latter can then be used to chloridize new oxidized solutions of copper. Mr. Laist's original patent is 903,732, Nov. 10, 1908, and was referred to in this journal Dec., 1908, page 510. (1,104,907, July 28, 1914.)

Copper, Nickel and Zinc

Treatment of Copper-Nickel Ores.—In our issue for January, 1913, page 55, we presented an abstract of a patented process for the recovery of copper and nickel from low-grade ores and products, the inventors being Professor **Wilhelm Borchers,** of Aachen, Germany, and **Harold Pedersen,** of Trondhjem, Norway. It has now been discovered by the inventors that their process can be simplified in its latter stages, and they have secured an additional patent. Following is a synopsis of the improved process.


Ore
smelted with limestone or leaching residue in the electric furnace.
Final products
Slag for making building material.
Crude matte
partly treated with sulphuric acid.
Sulfureted hydrogen.
Roasting to sulfates, leaching.
Leaching residue consisting of iron oxid and undecomposed nickel and copper sulfid.
Solution containing the greatest part of the nickel and copper in the form of F precipitated with sulfureted hydrogen.
(F) Sulfates.
Solution containing nickel sulfate, is evaporated and allowed to cool.
Sulfid of copper reduced to
Copper.
Mother liquor (lye) containing $NiSO_4$ and H_2SO_4
Nickel sulfate is dried and calcined.
Nickel protoxid is smelted with carbon.
Nickel.

The earlier patent is No. 1,043,291, Nov. 5, 1912; the current patent is 1,101,115, June 23, 1914.

Separation of Zinc Blende and Barytes.—The difficulty attending the mechanical separation of blende and barytes by ordinary methods of concentration are well known. According to specifications of a patent granted to Mr. **Charles J. Greenstreet,** of Webster Groves, Mo., a separation of these minerals can be effected by mixing them with a salt such as the chloride, sulphate or bisulphate of sodium and fusing the mixture. Under these conditions the barytes is mechanically combined and held in suspension with the molten sodium salt, while the blende is unaffected. The mixture eventually separates into two layers with the salt and barytes on top, and a separation can be made. On dissolving the salt, barytes is again precipitated. (13,735, Reissued May 26, 1914.)

Rare Metals

Vanadium.—Two patents granted to **Harold Boericke,** of Vanadium, Colo., disclose the inventor's modification of the usual manner of treating vanadium ores by roasting with sodium chloride to form soluble sodium vanadate. The objections to the usual procedure are the high temperature required for the reaction and the

consequent high fuel consumption. Mr. Boericke states that he has found that by the addition of a sulphide or a sulphate to the mixture the reaction takes place at a much lower temperature, with consequent reduction in the fuel consumption, and without material effect on the production of soluble vanadates. Thus 1 per cent iron sulphate added to the mixture has effected a saving of 50 per cent of fuel and has increased the capacity of the furnace 100 per cent. In case iron sulphide is added, it is first converted to sulphate during the reaction, after which it gives the same effect as though the sulphate were added originally. (1,105,244-5, July 28, 1914.)

Pyrophoric Alloy.—Mr. **Paul Faehr**, of the Elektrochemische Werke, Bitterfeld, Germany, patents "a metal alloy containing a metal of the rare earth group and one or more of the metals zinc, cadmirum, tin or lead in such proportions as to make the alloy pyrophoric" (claim 1). Examples are 40 per cent. cadmium and 60 cerium; 30 zinc and 70 cerium; 30 tin and 70 ncerium; 30 lead and 70 cerium; 10 zinc, 10 tin, 10 lead, 70 cerium. These alloys not only keep for an indefinite time when exposed to air, but also in the presence of moisture, neither are they affected by great changes of temperature, nor by being placed in water. (1,102,575, July 7, 1914.)

Metallurgical Furnaces

Sinter-Roasting Furnaces.—In the type of sinter-roasting machines devised by Dwight & Lloyd, the material to be sintered is deposited from a stationary hopper onto a moving grate that passes over a wind box. Ignition of the charge is started by a stationary source of heat and continued to completion by a downdraft of air. In a patent granted to Mr. **Francis D. Weeks**, and assigned by him to the Dwight & Lloyd Sintering Co., of New York City, the above order of operations is reversed, in that the grate and the charge of sintering ore are stationary, while the feed hopper, igniter and means for removing the sintered charge travel over the grate. The idea may be applied to either annular or straight-line machines. The advantages claimed for this modification of the process are that the charge of material on the grate is not disturbed in any manner, and less tax is placed on the machine in moving the weight of ore and grate. (13,758, Reissued June 23, 1914.)

An improvement in pot-roasting methods is patented by **Josef Savelsberg**, of Papenburg-on-the-Ems, Germany, whereby the usual formation of a layer of fine material at the top of the charge is prevented. Steam is added to the air blown through the charge, in sufficient quantity to condense in the upper cold layers, thereby moistening the mixture and preventing a separation of the material to be sintered from the parts of fuel. Part of the steam also is decomposed by the glowing fuel, forming water gas and promoting the sintering operation. (1,103,318, July 14, 1914.)

Grates for pan-roasters form the subject of a patent granted to **John E. Greenawalt**, of Denver, Colo. According to the improved construction the grate is made of interlocking sections, instead of one piece, and provision is made for expansion of the units when subjected to the heat of the sintering operation. (1,098,035, May 26, 1914.)

Another improvement in pan-roasters patented by Mr. **Greenawalt** consists in constructing the furnace in two sections, the lower one being the hearth and the upper the ignition chamber. These are made separable, and the upper portion can be transferred from one lower portion to another, thereby serving for the ignition of a number of charges on as many hearths. (1,103,196, July 14, 1914.)

Electric heating of the air supplied to roasting furnaces, such as the superposed hearth type, is disclosed in a patent granted to **Utley Wedge**, of Ardmore, Pa. It sometimes happens that air is not sufficiently heated by passage through the chambers provided between the hearths, and in order to supplement such heat the inventor proposes to construct electric heating chambers in the outer walls of the furnace, wherein resistance coils will insure the heating of the air to the proper temperature. (1,086,494, Feb. 10, 1914.)

Temperature Control for Industrial Purposes

Many chemical, metallurgical and industrial processes depend upon the careful maintenance of the temperature at a certain predetermined point. Thermostats are appliances which perform this function automatically. There are quite a number of thermostats on the market which are very successful for temperatures up to the boiling point of water. But the requirements of many industries call for an instrument which can be used quite as successfully for much higher temperatures.

In the following article we give a description of the Geissinger thermostat which can be adjusted to practically any temperature (being restricted only by the choice of materials of construction), and which is therefore applicable to the widest range of industrial processes. Before we enter into a description of this particular instrument, a few general remarks on thermostat design and on the classification of the different types of thermostats may be useful.

In most applications of heat in manufacturing processes the process has to be guarded against too high a temperature. For this reason Mr. Geissinger points out that valves which will close automatically when they are deprived of operative power give a higher guarantee of safety than automatic valves which are held open by a spring against air pressure upon a flexible diaphragm. While electricity supply is subject to rare interruptions, yet such may happen, and valves which will cut off the heating process in case of such failure follow the "safety-first" principle.

As to electric power versus compressed air or hydraulic power for the operation of valves, Mr. Geissinger points out that after all in general industrial practice electricity is proving to be most reliable and tractable force at the command of the engineer. While the electricity supply may fail in rare cases, yet Mr. Geissinger thinks an air-compressor has more reason to "lay down."

As to mechanical details of construction Mr. Geissinger lays particular stress upon the effect of heat and age upon diaphragm-operated valves. Should heat and constant flexure produce a crack in the diaphragm the valve would open suddenly.

Any properly working temperature-control apparatus breeds confidence and causes relaxation of attention. For this reason reliability on the "safety-first" principle, as explained above, is all important. Another requirement of any temperature control for industrial purposes is that it should "work close and keep working." If the investment of automatic temperature control is worth while at all in a heating process, the control cannot be too accurate.

We may now briefly discuss details of designs of various types of thermostats. They may be classed into two main groups: (I) Thermostats which operate valves directly, without any supplementary power and (II) thermostats which direct the operation of the valves with the aid of a supplementary power supply.

Group (I) may be subdivided into two classes. In (Ia) we have valves operated by the direct expansion of rods. The fact that the expansion coefficient of

the most expandable materials under 1 degree rise of temperature is small, and that this expansion must be sufficient to close and open the valve to its maximum requires that large dimensions be chosen for the expandable part, if close temperature control is desired.

As (Ib) may be classed those valves which are operated by the vapor tension of a liquid immersed in the material under control. The range of this type is limited by the boiling points of different fluids under reasonable pressure.

Group (II) in which a supplementary power supply is used and which comprises the majority of commercial instruments, may also be subdivided into two classes, according to whether (IIa) compressed air or water or (IIb) electricity is the auxiliary power supply.

(IIa) The instruments operated with compressed air (of a high coefficient of expansion) have expansion tubes of reasonable dimensions, called upon to open very small "leakage ports." This leakage operates a pneumatic relay, admitting air to close diaphragm-operated valves.

To the same class belongs the type making use of the vapor tensions of liquids in bulbs exposed to the material the temperature of which is to be controlled. Again, the motion of the diaphragm is limited to leakage control of the air supply to the diaphragm valve. The air ports are necessarily small and air-filters are an adjunct to these types of controllers, in order to prevent dust or oil (with which the air in manufacturing processes is often charged) from choking the fine air ports.

(IIb) In the electric thermostat class we find possibly both the oldest and latest forms of instruments.

We are all familiar with the compound bar made of plates of brass and steel riveted together. Such compound bar is fixed at one end and free to make contact on one or two points at the other end. The layers of metal must be made thin to produce a marked motion of the free end under changes of temperature. This same condition makes the whole structure a weak spring. This form of thermostat must be subject to several degrees change of temperature to create a small pressure between its contacts.

The effect of pressure on the contact resistance of two platinum contacts has been the subject of special investigation. Mr. Geissinger states he has found that an electric thermostat working under commercial conditions has to exert a pressure between the contacts of at least 0.01 lb. in order to close the circuit and that this pressure must probably be double with a trace of oil between the contacts.

Another modern type uses the vapor pressure of a volatile liquid, or the expansion of mercury in a bulb exposed to the material under control, operating the familiar pressure tubes of recording instruments, the index hand being equipped with one or two contact points. Mr. Geissinger states that "a mercury-filled temperature recorder-type thermostat with a pointer moving 0.3 in. for 10 degrees F. exerted a force of 0.02 lb. under restraint produced by a difference of 10 degrees F."

The sensitive portion of the Geissinger thermostat shown in the adjoining illustration consists of a metallic or vitreous tube with some coefficient of expansion, and an inner rod of an alloy of practically zero coefficient of expansion.

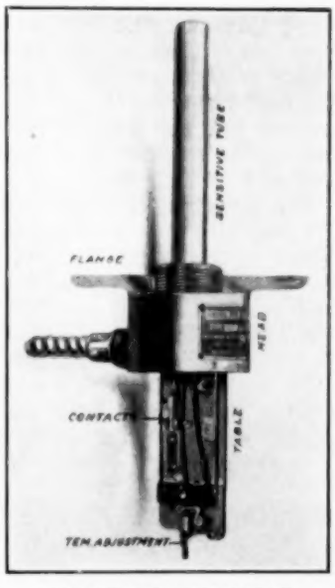
The tube is either cast integral with or welded to the head. The end of the tube is fused over.

There is bolted to the head a part called the table, carrying the electrical parts of the instrument, the "contact" and the "contact arch." The inner end of the contact arch is operably connected to the non-expanding rod, while the outer end is held in a piece united to the inner end of the table by flexible side bars. The side bars and contact arch are of the same length, section, and material. They expand equally under any temperature the head may be.

The free end is capable of considerable lateral movement on the table, on account of the flexibility of the side bars. Such movement is produced by the temperature adjusting screw operating through an angle lever. Displacement of this free end alters the distance between the contacts. Each adjustment demands a different expansion length of the sensitive tube to produce contact and consequently another temperature in the surrounding medium.

The contact arch is a normally flat piece of spring steel, forced into a shallow arch by end pressure, or shortening of the chord. It is evident that the movement of the vertex of such an arch is a magnification of the shortening of the chord, the relative motion being a function of the length over the height of the vertex.

Again, imagine a non-compressible shallow arch set in an inelastic chord, loaded in the center. Such arch can be loaded without change of shape, until it "breaks" like masonry. In the action of the thermostat the vertex of the contact arch is brought against the contact point, and apart from the end thrust and compression of the parts, instantaneously a force is obtained which "breaks" the arch into a curve with three radii. The pressure between the contacts after the "break" is 0.6 of the breaking load.



ELECTRIC THERMOSTAT

Now for any size and material the breaking force is proportional to the height of the vertex, and the longitudinal stresses uniform in all heights of vertex. It should be borne in mind that we have to do with curves with relatively long radii.

The rigidity of the contact mechanism permits the use of sensitive tubes of a very low coefficient of expansion, covering a wide choice of compositions appropriate to the temperature and chemical nature of the material under control.

The maximum contact pressures are variously set between 0.75 and 2 lbs. No matter how great the difference between the working and atmospheric temperature, the contact pressure when cold is 60% of the maximum. The compressive stresses are negligible, there is no "set" to the tube. If an instrument cools off once a week it keeps clean of oxide. If in fact anything interfered with the passage of the current between the contacts, it is at once crushed by a force that amounts to 0.9 lb. per deg. F. below the standard temperature. This comparatively very high force ensures the reliable working of the instrument.

The Geissinger thermostat is made by the Geissinger Regulator Company, 203 Greenwich Street, New York.

Borax.—In 1913 the production of crude borate materials in the United States was 58,051 short tons valued at $1,491,530, according to the U. S. Geol. Survey.

Repairing a Crank Shaft by Autogenous Welding

BY C. H. BURROWS

A chief engineer is frequently required to use unerring judgment in making extensive repairs in his power plant, and to make these repairs permanently durable and neat in appearance in a quick and economical way. An occasion which requires such ability comes unexpectedly and is usually attended by a complete shutdown of his plant. To keep himself forearmed for these emergencies, it is desirable to know of the methods and success other mechanics have had under such circumstances; and with a motive to contribute to his preparedness, I call attention to the prompt results and unusual success obtained in repairing a large crank shaft by autogenous welding with an oxy-acetylene torch.

The crank shaft was 6 in. in diameter by 11 ft. long, and was a member in a three-cylinder 100-hp producer-gas engine belonging to a single-unit electric-lighting plant.

It was broken square off through one of the arms and totally disabled the entire plant.

Just previous to the welding operation, the fractured ends were placed in a glowing bed of charcoal, and surrounded by brick to thoroughly preheat the portion adjacent to the fracture. This performance was not vital to the actual welding operation, but was only an economic measure to save gas. After preheating it was perfectly aligned on V blocks and with the torch a gap was cut on opposite sides. The sloping sides of the gap forming an angle of about 75 deg. with the vortex at the point of fracture, in the center of the shaft. This cutting was done entirely with the torch and left the sides of the gap dripping with molten metal, which condition penetrated the material of the shaft. In fact, it would be exceedingly difficult to determine just where this molten condition actually terminated. This fluid and semi-fluid state was maintained or renewed with the torch while the gap was being welded full of molten steel from the welding rod, working from the center of the shaft outward.

The weld was then finished by eventually melting away the superfluous metal and smoothing off with the torch. The apparatus and the torch used were those furnished by the Vulcan Process Company, of Minneapolis.

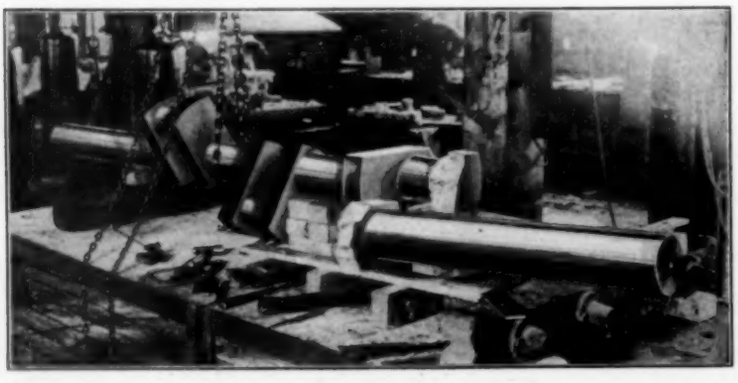


FIG. 1—CRANK SHAFT BROKEN

The complete job was welded and ready to deliver in less than twenty-four hours at a cost of about $26 as

8 hours welding time at 35c	$2.80
812 cu. ft. oxygen gas	16.24
817 cu. ft. acetylene gas	6.54
50 lb. charcoal at 1c	.50
	$26.08

After cooling the weld was found to be perfectly homogeneous in texture, void of fire-scale or oxidation, and machined freely.

FIG. 2—CRANK SHAFT WELDED

This crank shaft has now been in heavy service for several months and given perfect satisfaction.

Minneapolis, Minn.

Recording Gas Calorimeter

Primarily for use in gas power installations the Lexington Instrument Works, of Lexington, Ohio, has developed the Smith recording gas calorimeter which is perfectly automatic in giving the heat value of a gas (for instance, producer gas) per cubic meter. The record of the instrument is automatically corrected to the accepted standard of gas at 60 deg. Fahr. and 30 in. barometer. The readings are also practically independent of atmospheric conditions.

The equipment consists essentially of two parts, namely, the sampling pump and the calorimeter. The sampling pump is a small power-driven metering apparatus, which delivers continuously a measured and proportionate amount of gas and of ordinary atmospheric air. The gas and air are delivered from the sampling pump through separate pipes to the calorimeter, where the gas is burned in and with the air and the rise in temperature of the air recorded as a measure of the heat value of the gas.

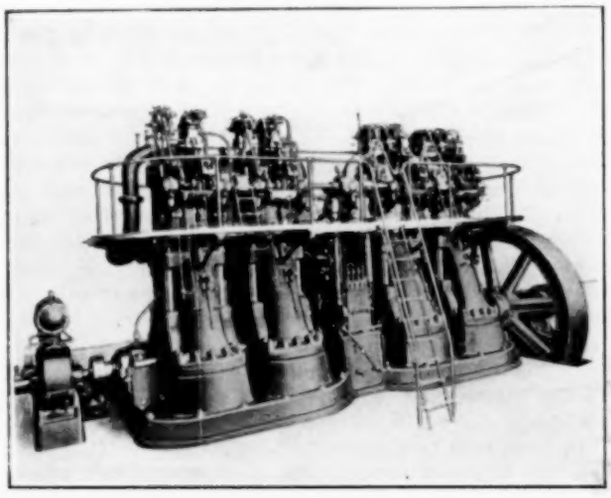
The instrument is designed primarily for use in gas-

power installations, to control the effectiveness of the gas for operation of the gas engine and also to control the efficient working of the gas producer. It may also be employed to advantage where gas is to be used for metallurgical purposes requiring fine temperature adjustments.

Large Oil Engine

The largest Diesel engine ever constructed in America will be the first piece of heavy machinery of this type taken through the Panama Canal.

The engine is composed of four huge cylinders and is capable of developing 690 horse-power. It was constructed in the immense plant of the Lyons Atlas Company of Indianapolis and has been sold to the Hawaiian Commercial & Sugar Company to be used for irrigation purposes in the Hawaiian Islands where it will operate pumps of 15,000,000-gal. capacity.



LYONS-ATLAS DIESEL ENGINE FOUR-CYLINDER, 600-660 BHP ENGINE WITH DIRECT-CURRENT-CONNECTED AIR COMPRESSOR

The big Diesel engine left the Indianapolis factory last month for Hawaii via the Panama Canal.

The conditions covering the acceptance of the engine were severe. The purchaser insisted that the engine should operate continuously 710 hours out of each 720 hours per month at rated load, using the ordinary 14° to 18° asphaltum base California fuel oil, similar to that used in the purchaser's steam plant, and which is the only grade available on the Islands.

The test was conducted by the chief engineer of the H. C. & S. Co., and the engine was given a preliminary continuous run of forty-eight hours with Eastern paraffine base fuel, after which all parts connected with the combustion chambers were inspected in order to determine a basis for comparison between the effect of the two fuels. It was then subjected to a 144-hour continuous run at full load with fuel shipped by the purchaser from California to the manufacturer's works. At the completion of this run the combustion chambers were again examined, and as there was no evidence of deposit on the heads, valves or pistons, the engine was accepted and is now en route to the Island, to be erected by their own engineers.

The **Fuller-Lehigh Pulverizer Mill** is the fifth of a well-illustrated pamphlet, issued by the Lehigh Car, Wheel & Axle Works, of Fullerton, Pa. It is particularly interesting on account of descriptions of equipment used for the production of pulverized coal suitable for heating industrial furnaces.

American Manufacturers and the European War

In reply to a request for an expression of opinion as to the effect of the war on metallurgical and chemical activity and on business in general, *Metallurgical and Chemical Engineering* has received numerous statements from American manufacturers.

Manufacturers of machinery for the non-ferrous metallurgical field refer to the cutting in half of the activity in copper smelters and refineries. One prominent manufacturer writes: "The effect of the war on our business has been that copper inquiries have stopped. One of our best orders has been canceled, and another was attempted to be canceled, but was already shipped."

Among the replies from steel manufacturers the following is typical: "We import from Europe ferromanganese and magnesite, but no alarming shortage of these materials has developed so far and we think the steel manufacturers will be able to secure all they will require, although probably at somewhat higher prices. This, of course, will have the effect of increasing the cost of steel making.

"The effect of the European war on our own business has been to curtail it and we look for somewhat decreased operations during the remainder of the year. This has been brought about by the inability to finance new enterprises, new buildings and the railroads. Spelter, of which we are large users, has advanced in price, owing to the alleged large demand from England, which, however, has only materialized in comparatively small tonnages. Spelter is in abundant supply in this country and will probably reach a normal price level within a few weeks."

Another manufacturer writes: "In the event of the supply of ferromanganese either being exhausted or the price becoming very high, ferrotitanium would undoubtedly be substituted therefor to a considerable extent so far as ferromanganese as a deoxidizer is concerned. In some instances, where titanium is being used, manufacturers have cut down to a certain extent the amount of manganese in their steel, although it is not wise to recommend such a change at this time."

The *Noble Electric Steel Company*, of San Francisco, Cal., states that anticipating the present conditions it has recently been preparing to manufacture ferromanganese at its electric smelter at Heroult on the Pit, and within the next ten days one furnace will be blown in, with the possibility of a second furnace being blown in a few days later. In California there are a great many manganese deposits, several of which are of considerable extent and of good grade, but inability to meet foreign transportation costs has caused these properties to remain idle. Now the Noble Electric Steel Company can enter the field of making ferroalloys of manganese and chromium. It will not be slow to take advantage of the opportunity the European war has created. The furnaces at Heroult are admirably adapted for the purpose, as metallurgical details for making ferromanganese are quite similar to those in making pig iron. The Noble Electric Steel Company expect to get a market for its ferromanganese not only in the steel works on the Pacific Coast, but also in Japan.

Mr. Wm. C. Cuntz, general manager and treasurer of the *Goldschmidt Thermit Company*, of New York City, says: "I do not see that our business will be affected by the war, other than in the general effect the war will have on all business. We are in position to manufacture practically all our material here and while certain raw materials are difficult to get and high priced at the present time, I am inclined to think

that this situation will soon straighten out, provided some way is found of putting the business of the country in the hands of business men rather than those of politicians, and provided also that economy is practised by these same politicians and everyone generally. By economy I mean not only in personal matters, but in the treatment of resources."

A prominent manufacturer of platinum ware states that "so far the effect of the European war has been to increase the cost by from 10 to 15 per cent, this being in part largely due to the increase in cost of transportation, insurance, war risk and exchange. For the present we have sufficient stock in hand to meet our customers' reasonable requirements, and as to the future a great deal would depend upon the duration of this trouble, for, as is probably well known, Russia is the chief source of supply. As to a substitute, the peculiar and noble qualities of platinum preclude the possibility of using a substitute in a great many instances or uses, and in this connection we might state that in some lines where they have attempted to use a substitute they have been forced to return to platinum. As yet we are unable to say anything definite as to the possibilities of South American trade."

Among electrochemical manufacturers, Mr. W. Acheson Smith, general manager of the *International Acheson Graphite Company*, states that its "supply of raw materials has not been interfered with in the least, and we are prepared to supply Acheson graphite in any quantity."

An electric-furnace operator states that the only supply he has been obtaining from Europe has been large carbon electrodes. "As these are now also made in this country we do not feel that the European war will affect us seriously in any way in manufacturing."

Mr. C. L. Allen, general manager of the *Norton Company*, Worcester, Mass., states: "We are not dependent upon European raw materials. We have received from time to time a few raw materials from Europe, but have never been dependent upon them. Whatever we require is available in this country. We are not looking for substitutes. As more or less abrasives have been imported it is possible that we may be able to supply some of our own in place of these. So far as our line is concerned the effect on export business ought to be favorable, but not now to a great extent because the demand for our goods is not fully developed."

Mr. Geo. E. Long, vice-president of the *Joseph Dixon Crucible Company*, states: "We have been dependent on Germany for clay for crucible making and for the clay which enters into pencil making. We would gladly have used an American clay if one could have been found suitable. So far none has been found. It is not a question of price but of material only. The Dixon company has also been obliged to look to Germany for its best quality of mineral colors and aniline colors. We are looking now, as we always have been, for these materials in our own country, and there are no substitutes so far that we have been able to find."

Activity in certain chemical fields is indicated in various replies from manufacturers of chemical apparatus and machinery, although several of them do not wish to be quoted for publication.

Messrs. *L. O. Koven & Brother*, of New York City, write as follows: "Very soon after hostilities commenced between the nations at war in Europe we received inquiries from a number of both large and small producers of chemicals for special apparatus, same to be used in the manufacturing of chemicals which until now, we understood, were manufactured abroad. In some instances chemicals, for which we have orders for special apparatus, were being manufactured here in some quantities, but as the foreign supply has been lessened it will be necessary to increase the output for such chemicals here very materially. In some cases chemicals which were not manufactured in the United States in the past are now, so we are advised, being made here. As a result of the increased production of chemicals in the United States we have received orders in the past few weeks for apparatus which we believe would not have been ordered of us had the conditions in Europe not changed. Some of the apparatus which we are making are duplications of what we made heretofore. We also contemplate the building of apparatus which will be duplicates of things now used abroad. . . . We believe that the manufacture of any chemical products which are once manufactured in this country will be continued. This has been the case in the metal lines. After the factories are once provided with the necessary equipment and the men familiar with the methods of manufacture, there is no reason why chemicals once manufactured here should not be made in competition with foreign goods."

Mr. F. J. Stokes, of the *F. J. Stokes Machine Company*, Philadelphia, states that his company is in nowise dependent on Europe for materials, but as its sales are mainly to the manufacturers of chemicals and pharmaceutical preparations, who have been seriously affected, sales have been slightly influenced. "Pharmaceutical manufacturers have been enjoying a sudden rush of business, which seems to be regarded by them as only temporary and, therefore, they will not purchase additional equipment. The same applies to the manufacturers of chemicals, although there is a disposition on their part to take up the manufacture of the products heretofore imported. The installation of new apparatus of this kind requires careful consideration and the increase of sales from this source will not be immediate.

"In reference to exports to South America, there has been an increase in requests for quotations. South Americans, however, are slow buyers, especially in apparatus of a technical nature, and considerable correspondence has to be entered into before they will place an order. We do not, therefore, look for much increase from them under two to four months."

Mr. F. M. de Beers, general manager of the *Swenson Evaporator Company*, of Chicago, Ill., believes that "the final result of the war, so far as American manufacture is concerned, is bound to be beneficial and that it will open up new fields of endeavor. So far as our particular business is concerned it will help us by eliminating some price competition in foreign countries, which resulted in so much of the business going to European manufacturers. As regards the purchasing of evaporators to be used in the United States, or in our neighboring countries, the war can hardly affect this one way or the other, as the best machines are built here, and the American purchaser knows enough to disregard a possible lower price of a foreign competitor. There is no immediate effect upon our costs, as most of our raw materials are produced here, but the financial condition is such that most new and large developments in the chemical industry are being postponed or abandoned."

Mr. R. L. Cawood, manager of the *Patterson Foundry & Machine Company*, of East Liverpool, Ohio, states that "we have hardly had sufficient time in which to judge what European conditions will do for America or what effect their troubles are going to have on our industrial condition. Theoretically, at least, their misfortune should be our opportunity. This should improve our export business to South America, as this country is now the logical source of supply for that territory and a great many of our products should find a ready market there.

"So far as importations of material into this country are concerned, I believe that this will temporarily work a hardship on a few manufacturers who are importing materials that are not at present made in this country. This handicap will gradually disappear as substitutes for these materials will undoubtedly be found in this country and similar materials manufactured here. This will mean increased industrial activity throughout this country. Goods like pottery, toys and other articles which are imported very extensively and which are no better than similar articles made in this country, will be made here in place of being imported. Two-fifths, or in other words 40 per cent, of our china and earthenware is imported. It is no better than the home product, but is made with cheaper labor abroad. The importation of these goods being shut off will undoubtedly help our own manufacturers.

"The stocks of imported goods in this country at the time of the European outburst were sufficiently large to tide over a great many consumers until the present time. Consequently we have not as yet felt the real effects of the changed conditions. In my opinion it will be sixty days more before we do so."

Another Middle Western manufacturer of machinery for chemical and allied industries, who wants to remain unnamed, says that "so far the effect of the war upon our business has seemed to be a quite general deferment of anticipated requirements. Our opinion is that the cutting off of certain supplies from Europe will result in a slow-up until other sources of supply or substitutes can be obtained or peace permits a resumption of deliveries. We believe the effect upon export business will be a curtailment until the war closes. It will take much time, careful, direct investigation and adjustment to ways and means that are not attractive but can, no doubt, be harmonized to mutual advantage if both interests pursue the policy of give and take."

The vice-president of a prominent Eastern manufacturing company, desiring to remain anonymous, writes: "A very large proportion of our business is with the railroads and while they are, as we all know, suffering from lack of supplies and equipment, they are not buying anything that they can possibly do without; nor do we see how they will be in a position to buy normally until there is some financial readjustment effected that will enable them to borrow money freely.

"We do considerable business with some of the larger industrial plants, one or two of which have held up a great many orders owing to the general financial situation. As far as we can see, this is more a measure of precaution than of necessity, however.

"We do not feel that the export business to South America will be of such a volume as is popularly supposed until this country is in a position to help them finance their operations. It is our observation that most of the South American countries are at present in financial straits, owing entirely to the European war and the manufacturers in this country are in no position at the present time to grant the long credits that have been customary with the English and German manufacturers on South American business.

"We believe that the railroads will eventually secure their 5 per cent increase and that the financial situation will slowly adjust itself to the new conditions, and that shortly after the first of the year business in general will return to a more normal basis.

"We feel, however, that it is going to be some time before the American manufacturers and foreign buyers can so rearrange their methods of buying and selling that any greatly increased export business will result. However, we feel that this business is bound to come in time, and that when the South American countries are once educated to the purchase of goods from this country that Europe will never recover the business."

The *American Vulcanized Fiber Co.*, of Wilmington, Del., makes the following statement:

"The raw materials from which vulcanized fiber is made, viz., cotton cellulose, coloring matter and zinc chloride, are all imported into this country in very large quantities. The European war has, of course, stopped the importation of these commodities, with the result that the cost of all our raw materials is steadily increasing. Unfortunately, no substitution can be made without more or less seriously impairing the quality of the finished product.

"For instance, cotton cellulose in the form of rags costs now $10 to $20 per ton more than a month ago. We have our own mill which separates directly from the cotton hulls a very pure cellulose which we use largely for certain grades of vulcanized fiber, but we also use large amounts of cotton cellulose in the form of rags, the price of which in this country is regulated by the European supply.

"It is at present almost impossible to get aniline colors, and manufacturers of fiber in common with many others will be forced to depend entirely upon mineral pigments, with the inevitable result that the price of these will be forced up. Certain colors will probably have to be discontinued after the supply of coloring matter now on hand runs out.

"The price of zinc chloride and even the available supply is likely to be seriously affected by the war, as is seen by the fact that large quantities were imported from England and Germany in 1913. We ourselves are somewhat more fortunate than most, because we have an independent source of supply for zinc chloride which will not be affected by European conditions. In this connection we are glad to state we shall have during the next twelve months an excess of this chemical, which we can deliver in our own tank cars as a C.P. or commercial solution of any desired strength. We also have our own supply of pure red oxide pigment, and expect to be able to offer some of this for sale.

"The immediate effect of the war is to reduce very materially domestic sales of our finished product. In our opinion the ultimate effect of the present war may be to stimulate the export business with countries other than Europe, but it is not to be expected that this will make up for the loss of the European trade, for industries in those countries have not developed along lines that require vulcanized fiber in the large quantities that are used abroad, and we are, of course, in general adjusting our organization to meet the changed conditions."

Mr. F. R. Still, secretary of the *American Blower Company*, of Detroit, Mich., thinks that in spite of some discouraging indications "there is every reason for believing that business should be good, and it will if everybody will keep cool and proceed cautiously and steadily. It will take some time to adjust finances to the changed conditions and still longer before business gets up the momentum to meet the coming demand, during which period expenses and credits must be watched carefully. 'Necessity is the mother of invention'; this war will be an incentive to find substitutes for many materials we all have been accustomed to use, or to induce capital to invest in the production of old material heretofore produced in Europe almost exclusively. The final result will probably be much the same as was the building up of the tin plate industry under the McKinley tariff; when capital was offered the inducement it went into it and soon got onto a footing that almost excluded foreign competition.

"Our company has been dependent on the European countries for raw material only in a limited degree, such as tin, manganese, plumbago, etc.

"South America is reported to us to be in a bad way financially and business is almost at a standstill. If our Southern neighbors can place large loans in this country, and branch banks be established down there and capable representatives be sent to canvass their wants, and goods be made to suit their demands, then a big business should ultimately be the fruits of such efforts, but this is a long time away and with characteristic American impulsiveness, many are likely to become discouraged in their efforts before the successful conclusion of such a campaign is reached. If the war lasts long enough to enable this country to get started in foreign fields, Europe can never overtake us in this or the next generation. But should it suddenly cease, in the near future, we will find ourselves just where we were before it started."

Mr. W. F. Graver, vice-president of the *Wm. Graver Tank Works*, of East Chicago, Ind., states that they "have been selling storage tanks to some of the refiners who export petroleum products to the European countries, and this business is necessarily curtailed until the existing conditions abroad are changed. On the other hand, the curtailment of petroleum shipments has increased the need for storage in this country and some of the larger companies are buying considerable tankage to take care of the production.

"As to the effect on export business, I would say that benefits must necessarily accrue as far as the steel line is concerned as the greater part of material in this line for South America, the Islands and Mexico are shipped from Germany. As far as our line is concerned, our experience would indicate that a large amount of export businss is lost annually through indifference and unfamiliarity with foreign requirements and conditions. We believe that, once established, our trade with South America will be permanent.

"We also believe that the existing conditions will convince the American manufacturer of the undesirability of being entirely dependent upon foreign countries for raw material and that they will not overlook the opportunity to develop industries which are now perfected abroad, and to draw on our vast resources for substitutes to replace foreign produced raw materials now unavailable. These changes must eventually come and the present state of affairs makes it imperative that the changes come now."

Mr. Irving C. Jennings, manager of the *Nash Engineering Company*, of South Norwalk, Conn., states that "business fell off somewhat with the start of the war, but is now picking up again."

Mr. *A. J. Weeks*, manufacturer, of Akron, Ohio, states that they have everything they need for manufacturing chemical stoneware in Ohio, so that they are affected by the war only as far as the general business is affected. "The tariff revision did hurt, as it placed foreign ware on less duties into this country. This war may help us somewhat in the near future, cutting off foreign importations. It will take time and facilities to get into exporting to South America. In the end I consider the war will not be of great benefit to this country as calamities usually spread and affect all the conditions of the world."

Mr. *Maurice A. Knight*, of East Akron, Ohio, states: "As Germany imported a good deal of acid-proof stoneware, we now expect to get our share of what was their business. Our ability and equipment to get out our product has not been affected in any way. I have had more inquiries from South America in the last six weeks than ever before."

Mr. F. E. Finch, of the *Ruggles-Coles Engineering Company*, of New York City, staes that they have had several orders canceled, especially for foreign shipments, due to the present war, but have also received inquiries and orders from companies and individuals who would usually go to France or Germany for their machinery. "We expect to increase export business to South America, and hope to place that on a firm foundation."

The manufacturer of a chemical commodity which is largely used in the electrical industries, writes: "The volume of our business would be almost entirely dependent upon the prosperity of the general electrical manufacturing industry of this country. How this is to be effected by the present European situation is more than the writer can vouchsafe to answer.

"We have not reduced or increased our organization recently, although our business continues to maintain itself in a very healthy condition. We have so far been almost entirely dependent upon Europe for certain supplies, but it is the writer's opinion that if the interruption to European manufacture and export continues for any length of time the coke producers of this country will desist from wasting their by-products."

The president of a company making special electrical machinery who likewise wishes to remain anonymous, states: "Up to the present time we have not been seriously inconvenienced by being cut off from European raw material. Very little of such materials have entered into our devices and we were fortunately well provided with such minor items as solder, etc., which do not enter in large quantities into the construction of our apparatus. Simultaneously with the outbreak of the war there was, and still continues to be, a marked increase in business, and we have traced a number of these orders to electrochemical and electrometallurgical organizations which will endeavor to supply materials which have formerly been coming from abroad. Our bulk of business on hand at the present time exceeds that which we had on hand a year ago. We do not look for any great increase in orders for special transformers from the South American trade, but will expect to profit indirectly from the business which the electrochemical and electrometallurgical industry of this country will undoubtedly secure."

Messrs. *Merck & Company*, of New York City, have issued an Emergency Price Guide for temporary service. One strong recommendation made in it is to use sodium salts instead of potassium salts wherever possible. "The sodium salts, of which there need be no more than a temporary lack, deserve to be more widely issued, and we would urge all our friends to use them in all cases where they have been in the habit of using the potassium salts, because of the constant source of supply."

Mr. Chester G. Fisher, vice-president and general manager of the *Scientific Materials Company*, of Pittsburgh, Pa., says: "A large portion of our chemical apparatus has been made in Europe. The principal reason for making many of these articles in Europe is not because they could not be made in this country, but because they could be made in Europe considerably cheaper. We are at present manufacturing many articles here in Pittsburgh which we have heretofore made abroad, but the cost of these articles is considerably greater than the same articles made in Europe. There are, of course, some articles which have been developed to a very high degree in Europe which would take a long time and considerable research work to equal were we to make them in this country, and on such articles we have no recourse but to wait until the European situation adjusts itself."

A pyrometer manufacturer who wants to remain anonymous states that he has been importing considerable raw material from Europe and when his supply runs out he expects some difficulty in obtaining them. The war has also affected his export business to Spain, Sweden and other countries.

Mr. C. H. Wilson, of the *Wilson-Maeulen Company*, of New York City, writes: "As most of our importations are from England, these have not been materially disturbed. There are some few things which we have obtained from the Continent which we can unquestionably replace from local sources. In this connection it seems that someone should point out to the American manufacturer that when someone comes to him to replace what that someone has been heretofore obtaining from Europe, the American manufacturer should take a keen interest in the prices and qualities of what has heretofore been imported, otherwise the American manufacturer can hardly be very sure that he will hold the trade when European business gets back somewhere near the normal. That is to say, even if he finds his customer willing to accept what he has to offer, he should bear in mind that that customer may be accepting it as a temporary shift and that this is the time when he should display such keen interest in the requirements of his customer and should expend such efforts to meet the requirements as will insure permanently holding the business."

Personal

Mr. **Franklin Guiterman** spent the month of September at the Denver office of the American Smelting & Refining Co. Mr. **L. G. Eakins,** manager of the Colorado department of the company, was absent on vacation.

Mr. **Stuart S. Bruce** has resigned his position as professor of metallurgy at the Michigan College of Mines, and will be out of professional work for a time. At present he is at Victoria, B. C.

Mr. **W. J. Pentland,** manager of the Amajac Mines Co., has returned to Mexico and will make an effort to renew the work of constructing a cyanide mill. He will be at Hotel Cosmopolita, Guadalajara, Jalisco, for a time before going on to Hostotipaquillo.

Mr. **J. B. Tregloan,** superintendent of the McNamara mill, Tonopah, Nevada, has returned to his duties after an extended trip east.

Mr. **D. L. H. Forbes** has been appointed chief engineer of construction for the Chile Exploration Co., and has gone to Chuquicamata. He was formerly on the staff of the Merrill Metallurgical Co., and consulting engineer for the Trethewey mine at Cobalt.

Mr. **W. P. Lass,** superintendent of the cyanide plant of the Alaska-Treadwell Gold Mining Co., resigned his position, effective Sept. 1. He will open an office in Juneau with Mr. **E. P. Kennedy** and give attention to the development of the Speel river hydro-electric power project.

Mr. **Frederick Lyon,** vice-president in charge of operation for the U. S. Smelting, Refining and Mining Co., is making a tour of the company's plants in California, Arizona, Indiana and New Jersey.

Mr. **C. B. Lakenan** is reported to be recovering satisfactorily from an operation recently performed at the Mayo hospital.

Mr. **Andrew W. Newberry** visited Utah and Colorado mining districts following the Salt Lake meeting of the American Institute of Mining Engineers.

Mr. **William W. Clark** has resigned as chief chemist and metallurgist of the American Vanadium Company to accept a position as metallurgist with the Seymour Manufacturing Company, which will install a metallurgical laboratory.

Prof. **Joseph W. Richards,** of Lehigh University, has returned from Europe via Copenhagen. He was in Germany when the war started.

Obituary

James Porter Evans died suddenly at his home, 1427 Franklin St., Denver, Col., on Sunday evening, September 13.

Born at Zanesville, Ohio, November 29, 1860, he came to Denver in 1881 and engaged in the railroad business. He continued in that field, rising through various positions to that of auditor of the Denver and Rio Grande Express, which connection he severed in 1895 to enter the Colorado Iron Works Co. of which he was vice-president and general manager at the time of his death.

His activities in connection with the development and manufacture of mining and smelting machinery brought him into intimate contact with many men of note, and in his sudden demise the mining industry loses a prominent figure.

Mr. Evans had drawn to himself a wide circle of friends who had become endeared to him through his upright character and genial disposition. Upon these his loss will fall as a personal bereavement. He had long suffered from asthma and the fortitude with which he bore up under repeated severe attacks of this ailment was a source of admiration by his intimate friends. Taken with pneumonia on Wednesday but few knew of his illness and none feared its fatal termination. He belonged to Oriental Lodge No. 87, A. F. & A. M., of which he was a charter member, Denver Commandery No. 25, Knights Templar, and of El Jebel Temple, A. A. O. N. M. S. He was also a member of the American Institute of Mining Engineers, the Denver Club and the Denver Country Club.

He is survived by his widow, Mrs. Isabel Nesmith Evans and one daughter, Elisebeth.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

AQUEOUS BATH (ELECTROPLATING) *Continued*

570,554, Nov. 3, 1896, Eduard Jordis, of Munich, Germany.

Relates to the art of electrodepositing metals or alloys, and also to scouring or cleaning by electrolysis, and consists in the employment of lactic acid or lactates in the bath. When employing pure solutions of the required metal lactate, such metals as nickel, iron, copper, and zinc are deposited and have a dark velvety color. By the addition to the electrolyte of alkaline lactate, and sulfates or other salts of more electropositive metals than the metal to be deposited, such as aluminium, magnesium, etc., the color of the deposited metal will be lighter, so that many shades of deposited metal may be contained, by adjusting the conditions of concentration, temperature, and current density. The conditions for electrodepositing several metals are given.

571,531, Nov. 17, 1896, Rudolf Langhans, of Berlin, Germany.

Relates to the electrolytic production of oxide coatings of the earth and alkaline earth metals. To a solution of a salt of an earth or alkaline earth metal is added the hydroxide of the same or different base, and dissolved therein with the aid of heat; the resulting solution is electrolyzed with insoluble electrodes, with high or low current density, a deposit of a hydrated oxide separates out and adheres more or less closely to the negative electrode according to the condition of the electrolyte and the circumstances of the electrolysis. The

conditions are given for obtaining deposits of the hydrated oxides of zirconium, thorium, yttrium, aluminium, and magnesium; and for obtaining an oxide deposit upon a wire mesh incandescent gas-light mantle.

571,532, Nov. 17, 1896, Rudolf Langhans, of Berlin, Germany.

Relates to the electrolytic production of oxide coatings of the earth or alkaline-earth metals which will be porous and both cohesive and adhesive. Aqueous solutions of the water soluble or "meta" hydroxides of the earth or alkali-earth metals are well adapted for this use. A diluted solution is employed, containing about 3 per cent, for example, of the water-soluble hydroxide of thorium, and electrolyzed with a current of 0.03 amp per sq. cm. The deposit is a perfectly cohesive and adhesive layer of insoluble hydroxide, which may be calcined to the oxide without loss of these properties. The soluble hydroxide can be prepared as follows: oxide of thorium obtained by ignition of the oxalate is heated with excess of nitric acid, or hydrochloric acid. When the excess of acid is expelled by heating in a water-bath a residue is obtained which is soluble in water.

The patent refers to a co-pending application which became patent 571,531.

571,533, Nov. 17, 1896, Rudolf Langhans, of Berlin, Germany.

Relates to the conversion of precipitated hydroxides, such as described in patents 571,531 and 571,532, into insoluble or difficultly soluble salts, which are easily converted into oxides by heat. The electrode on which the hydroxide is precipitated is connected as an anode, to a weak source of electricity, and placed in a solution containing, for example, selenious acid, tartaric, oxalic, formic, tannic, or carbonic acid; the current immediately transforms the hydroxide into the corresponding salt or salts. The coated body is next removed, washed and calcined.

598,313, Feb. 1, 1889, Ernest P. Clark, of New York, N. Y., assignor of one-half to Charles S. Campbell, of same place.

Relates to depositing lead in a "feathery' finely divided condition. A solution is made by adding 1 lb. 10 oz. of acetate of lead to each gallon of water, the excess of acetate not dissolving being suspended in a coarse cotton bag near the top of the solution. The lead is precipitated as a frothy deposit by clean metallic zinc, the excess of lead acetate dissolving as lead is precipitated, the precipitation being stopped when the solution reaches a specific gravity of 18 or 19 deg. Baumé. The solution will now have a light-brown color.

Upon then inserting a lead anode and lead cathode, and passing a current, a deposit will appear which may at first consist of bright crystals of metallic lead, or a frothy deposit. After some time a feathery deposit will appear; the other deposited lead is then entirely removed from the solution, and deposition continued. After some time the brown color disappears, and the solution becomes entirely clear. The feathery deposit is said to be useful in making accumulator plates. It is stated that a deposit of this character cannot be produced by mixed solutions of zinc acetate and lead acetate.

602,872, April 26, 1898, Joseph W. Richards and Charles W. Roepper, of Bethlehem, Pa.

Relates to producing compounds by electrolysis with an alternating current. An application of the process is as follows: on immersing an anode and a cathode of cadmium in a solution containing 10 per cent of sodium hyposulfite and passing either a frequently reversed current, or an alternating current, sulfite of cadmium will appear as an insoluble coating on each electrode, the hydrogen evolved at the electrodes on reversal, mechanically disengaging the sulfide, which falls to the bottom of the vessel, and keeps the electrodes clean.

607,484, July 19, 1898, Josef Rieder, of Munich, Germany.

Relates to obtaining reliefs in metal by electrolysis for dies, etc., and consists in first making an impression of the relief on a porous block of plaster of paris, etc., or in engraving the same upon a suitable porous stone, saturating the porous block with an electrolyte that will dissolve the metal to be etched, placing the metal to be etched on the impressed or engraved side of the stone, connecting it as anode, and a suitable cathode on the other side of the stone. On passing a current, the anode is dissolved only at the points of contact with the stone, the pressure of the plate against the stone maintaining contact. The plate is eventually dissolved off so as to produce an exact counterpart of the impression in the stone.

A modification shows the lower part of the stone and the cathode immersed in an electrolyte.

Book Reviews

Chemical Analysis of Special Steels. By **Dr. Charles M. Johnson.** Second Edition, rewritten. 438 pages, 39 illus. Price, $3.00. New York: John Wiley & Sons, Inc.

The author is chief chemist of the Park Steel Works of the Crucible Steel Company of America, and his work is devoted to the development of rapid methods, especially for routine work. He covers all phases of the treatment of alloy steels, including annealing and sampling. Numerous methods are given, together with results obtained and precautions required. There are some reprints of papers presented by the author before the American Chemical Society. Methods of analysis of pig iron, carbon steels, together with chapters on raw materials, oils, coal, crucibles, etc., are included.

Plans are given of the Park Works Laboratory, together with photographs, and a description of special appliances, an annealing furnace and a water still. Special apparatus are described and illustrated, and particular attention is given to the laboratory electric furnace. It would have been a valuable addition had the author added an account of his elaborate methods of personal supervision and control over his laboratory force; this should be done in another edition. The book is otherwise most complete and valuable. It should occupy a well deserved position in all steel laboratories.

* * *

The Metallurgy of the Non-Ferrous Metals.—By **William Gowland**, F.R.S., A.R.S.M., 496 pages, 195 illustrations, 4 folding plates. One of a series of treatises written by associates of the Royal School of Mines. Price $5.00. London: Charles Griffin & Co.; Philadelphia: J. B. Lippincott Co.

This book is one of the series edited by the late Sir Roberts-Austen and whose authors are largely his old pupils. As such it deserves respect and attention. This book in particular is not up to the high standard of the series, for it is merely a compilation of data taken from standard American treatises such as Hofmann's, Peters' and Ingalls', and data from the American technical journals. The compilation is, however, well done, and while not as extensive as might be wished, yet the condensed product is available for use by the busy metallurgist, and the book is one which might well be on the shelf of the metallurgical engineer.